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THE SCIENTIFIC MONTHLY

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THE SCIENTIFIC MONTHLY

NOVEMBER, 1920

THE RÔLE OF PHYSIOGRAPHY IN MILITARY OPERATIONS[1]

By KIRK BRYAN

UNITED STATES GEOLOGICAL SURVEY

INTRODUCTION

STUDY of the terrain is an essential preparation for military operations. Under terrain, students of military science include all the features of the land surface, whether natural or artificial, which affect the movements and disposition of troops either on the offensive or defensive. The relative importance of the terrain in a military problem varies obviously with respect to other factors, such as the strength, disposition, and morale of both enemy, and friendly troops, and the proportion of infantry to the other arms present. It may be safely assumed that the terrain will enter into the solution of nearly every military problem. The features of the land surface under various names, such as topography and land form, are the principal study of the modern school of physiographers and geographers. Physiographers are concerned with the origin of the topography of the earth's surface; geographers with the relation of this topography to the habits and character of man. The methods and results of these scientific inquiries into the nature of topography may, however, be readily adapted to the needs of military operations. This relation between physiographic and military science was first recognized by the French, though their use of physiographic material in the late war was subconscious rather than conscious.[2]

[1] Published by permission of the Director of the United States Geological Survey.

[2] Brooks, Alfred H., "The Use of Geology on the Western Front," U. S. Geol. Survey, Contrib. to General Geol. Prof. Paper. In press.

Marga, A., "Géographie Militaire," 5 vols. and atlas, Paris. 1884–1885.

Where operations are on a large scale, neither the responsible general officers nor line officers have sufficient time or opportunity for detailed study and analysis of the terrain. They must rely for information on the maps and reports of others. The preparation of these reports, in so far as they pertain to terrain only, can best be done by geologists trained in physiography. The same methods and observations which they are accustomed to make for scientific studies serve equally well for military purposes.

The preceding generalizations have resulted from my service in the late war, and the following paper divides naturally into two parts: (1) a personal account of the use of physiography in actual operations; (2) suggestions for the application of physiographic information and for the utilization of geologists in the future.

The preparation of the paper has been greatly facilitated by the generous and constructive criticism of Mr. A. H. Brooks, formerly Lieutenant Colonel, Engineers, and chief geologist, A. E. F., Major Lawrence Martin, G. S., Lieutenant Colonel A. M. Prentiss, C. W. S., and Messrs. N. C. Grover, H. G. Ferguson, Sidney Paige and John S. Brown.

Experiments in the Use of Physiography

Organization of the 5th Army Corps

Through the operations of the Selective Draft, I found myself on June 30, 1918, a private in Headquarters Detachment of the 5th Army Corps. An army corps is the administrative unit which supervises three or more divisions and is, in turn, subordinate to the army. The newly organized 5th Corps had headquarters at this time in Remiremont, Vosges, and the commanding general had administrative but not tactical control of two divisions which were in training under a French Corps commander on the Alsace Front. The headquarters staff was divided into three sections, of which the second, known as the Intelligence Section, or simply G–2, had to do with information regarding the enemy, morale behind the lines, and counter espionage. Colonel George M. Russell, a regular army officer, was in command of this section of the Staff consisting of 12 officers and 59 enlisted men. Maps, map-making, and drafting for the corps were handled by a subdivision of G–2 called the Topographical Section, or G–2–C, in which I was enrolled as a

Barré, O., "Cours de Géographie, and Croquis Geographique, l'école d'application de l'artillerie et du genie," Fontainebleau, 1897–1900.

draftsman. Lieutenant Reuben A. Kiger, a topographical engineer of much experience on the United States Geological Survey, was in charge, and later he was assisted by Lieutenant R. B. Holmes.

My time for the first month was occupied in improving my technique in drafting and in learning the routine of Corps procedure. The officers of the Corps were also engaged in adjusting themselves to their new duties and not the least of their problems was to learn the use of maps. Largely recent civilians, lawyers, business men and engineers, they had paid little attention during their early education to topography and maps. Their army training was so brief and crowded that these studies had seemed less important than infantry drill and army paper work. Colonel Russell with his West Point training and Lieutenant Kiger and Lieutenant Holmes with experience on the Geological Survey were quite exceptional in starting in on Corps duties with an adequate knowledge of maps. While frankness compels us to admit this serious deficiency, one should bear in mind the remarkable achievements of this organization. The French consider that the building up of a Corps Staff is a matter of years yet the 5th Corps within two months of its organization began the successful St. Mihiel drive and two weeks later formed the center of the line in the Argonne in one of the most stubbornly fought engagements in history.

At the close of the St. Mihiel drive, the Corps had settled down in its routine work and a very keen appreciation of the value and use of maps had arisen. The Topographic Section was now called on for maps of many different scales and for many different purposes.

Block Diagram of the Argonne Region

The first rush of the Argonne offensive, beginning September 26, was remarkably successful. But because of increasing resistance and our inability to bring forward artillery fast enough, we were hung up before Cierges from September 28 to October 4. Again from October 5 to 8 we were stalled near Gesnes, by the outpost defenses of the Kriemhilde Stellung. The First and Third Corps on either side were in similar difficulties.

Many of our troubles arose from lack of appreciation of the terrain. Around Corps Headquarters many officers did not seem to have an adequate conception of the country in which the Corps was fighting, nor its relation to contiguous territory.

This impression, based on the gossip of Headquarters available to enlisted men, seemed to reflect a state of mind prevalent throughout the whole organization. Divisions and smaller units had of course even less information than we had, but had the advantage of seeing the country immediately in front of them. Lack of appreciation of topography was general and, while excusable, a condition which could be easily remedied.

A number of our officers had read D. W. Johnson's book on "Topography and Strategy of the War" and they testified that it had given them an invaluable conception of the topography of the theater of war in France. I could not, of course, judge of the correctness of Johnson's views on strategy, but his method of presentation is excellent. His topographic description is based on the best physiographic information and is built around and constantly refers to a simple block diagram of eastern France. Accordingly, I began work during time free from other duties, on a block diagram of the Argonne Region, similar in style to Johnson's diagram of eastern France.

The diagram is reproduced in Fig. 1, having been redrawn and slightly modified to conform with the detailed geologic maps now available. At the time, the only source of information was a school atlas of France. The text, reproduced below, has also been altered to conform more nearly to my present conception of what such a topographic description should be. The diagram and text are, however, essentially the same as when they were issued as a supplement to the Corps Summary of Intelligence. It will be noted that there is no discussion of strategy or tactics, which are not considered to be within the province of the Intelligence Section.

Military Topography of the Argonne Region

The Argonne Region as a field for military operations has certain striking topographic features. The Argonne and adjacent territory from our front line northward consists of six distinct belts of country. As shown in the block diagram attached, these regions, beginning at the west, are: (1) Escarpment of the Dry Champagne (Champagne Pouilleuse), the crenulated edge of a plateau; (2) Aisne Valley (Champagne Humide), a lowland; (3) Forêt d'Argonne, a rugged ridge; (4) Aire Valley, a flat-bottomed valley with rolling country on the east; (5) Côte de Meuse, a deeply incised plateau; (6) Wovere Plain, a lowland. The topography of each of these regions is carved from the underlying rocks which form the rim

of the Paris Basin. These rocks are great sheets of limestone and shale which dip gently beneath the ground to the west and southwest like the edges of a nest of saucers with Paris in the center. Each bed of limestone forms a ridge with an abrupt slope on the east, and a gentle westward slope. The shales form lowlands between the ridges. The ridges thus formed are: (1) Escarpment of the Dry Champagne; (2) Forêt d'Argonne; (3) Côte de Meuse.

Fig. 1. Block Diagram Showing the Relation of Topography to Geology and to Military Operations in the Argonne Region.

The Escarpment of the Dry Champagne is about 60 meters high, and is in many places cleared and cultivated, yet the branching ravines which indent the border of the escarpment and drain eastward to Aisne River afford excellent cover for artillery. The rough country yields many places suitable for local strong points. The effectiveness of this topography for defensive operations is shown in the recent resistance of

the enemy on the line Monthois-Livry-Orfeull, west of Challerange.

The Forêt d'Argonne ridge rises 100 meters above the adjacent valley of the Aisne. It is much higher and more rugged than the Escarpment of the Dry Champagne. The scanty soil and steep slopes have led to its being used almost exclusively as timber land and there are few clearings and few roads. The ridge is divided by the valley of the Aire River at Grandpré. North of this gap it is not so bold or conspicuous and gradually fades out into isolated wooded hills in the vicinity of Attigny.

The Côte de Meuse lies parallel to the Forêt d'Argonne at a distance of 25 to 30 kilometers. The eastern border of this plateau is a particularly bold escarpment rising about 250 meters above the Woevre Plain. Against the eastern face of the plateau the waves of the German advance broke in 1914. The canyon of the Meuse River divides the ridge diagonally between Verdun and Dun-sur-Meuse. The serpentine bends of this flat-floored canyon prohibit its use as a ready means of advance across the ridge, yet the sharp bends and projecting spurs prevent long-range observation and render sections of the canyon, once occupied, of great value for the location of supply lines. The tributaries of the Meuse entering from east and west have cut sharp ravines in both walls of the canyon and converted the plateau into a succession of cross-ridges. Over these ridges and astride the river the Crown Prince advanced in his assault on Verdun. In turn, over the same successive ridges, the Allies are now advancing northward. The advantage of topography is, however, with the Allies, for the Côte de Meuse decreases in height toward the north and fades out into isolated hills and ridges at la Bar River.

The lowlands of the regions are: (1) The Aisne Valley; (2) The Aire Valley (from Varennes to Buzancy); (3) The Woevre Plain.

The Aisne Valley, or more properly the Valley of the Upper Aisne, is the northern representative of the Wet Champagne. The soil is clayey and tends to be boggy in wet weather.

The district from Varennes to Buzancy may be considered as a lower belt of country between the Forêt d'Argonne and the Côte de Meuse, or as the lower slope of the latter ridge. It is bordered on the west by the valley of the Aire River. This valley is narrow from Varennes to Grandpré, but north of the Grandpré a similar but broader lowland extends northward to the pass east of Attigny. East of the Aire valley, the country is a rolling plateau drained by streams which flow west to Aire

River in rather broad, smooth valleys, and by streams which flow eastward to Meuse River in narrower, steeper valleys and ravines. The interstream areas are broad and smooth, and rise to similar elevations except for isolated hills or groups of hills which stand as knobs on the generally smooth upland. Such knobs are the hills at Vauquois and Montfaucon and the clump of hills southwest of Romagne-sous-Montfaucon. The woods are usually located on the divides and isolated hills. Offensive operations in such a country consist in the taking of one east-west ridge after another. Possession of the wooded ridge crests and the isolated hills gives the best observation posts and largest field of fire. That these features are thoroughly appreciated by the enemy may be seen in the skill with which the Kriemhilde Stellung has been located so as to take full advantage of this topography.

The Woevre Plain, underlain by soft and impervious shales, has two primary characteristics: It is very flat, and very muddy in wet weather. The plain, however, narrows rapidly north of Verdun, and from Stenay northward gradually disappears in the gently-rolling country of the pass of the Sedan. Once the Côte de Meuse is completely held, the Woevre Plain forms no obstacle to an advance into Sedan.

The pass of Sedan lies between the ridges previously mentioned and the rough mountainous country called the Ardennes. Traffic from the east follows the valley of la Chiers River. West of Sedan the Canal d'Ardennes runs southwestward up the valley of la Bar River, and then over a low divide to the Aisne River at Attigny. The pass of Sedan, comprising the valley of the Meuse from Sedan to Mezières, is the route along which runs the main line railroad Metz-Conflans-Longuyon-Montmedy-Sedan-Mezières. This portion of the railroad is the central section of the great "ligne de rocade" which parallels the German front in the west, and over which troops are shifted laterally along the line. The cutting of this line at Sedan is topographically practicable once the Forêt d'Argonne and the Côte de Meuse are held.

The Attack of November 1, 1918

From October 8 to October 16 our Corps was occupied with the slow and painful assault on the Kriemhilde Stellung, which ran among the wooded hills southwest of Romagne-sous-Montfaucon. This German defense position had been provided with wire but the trenches had only been marked out and not dug to

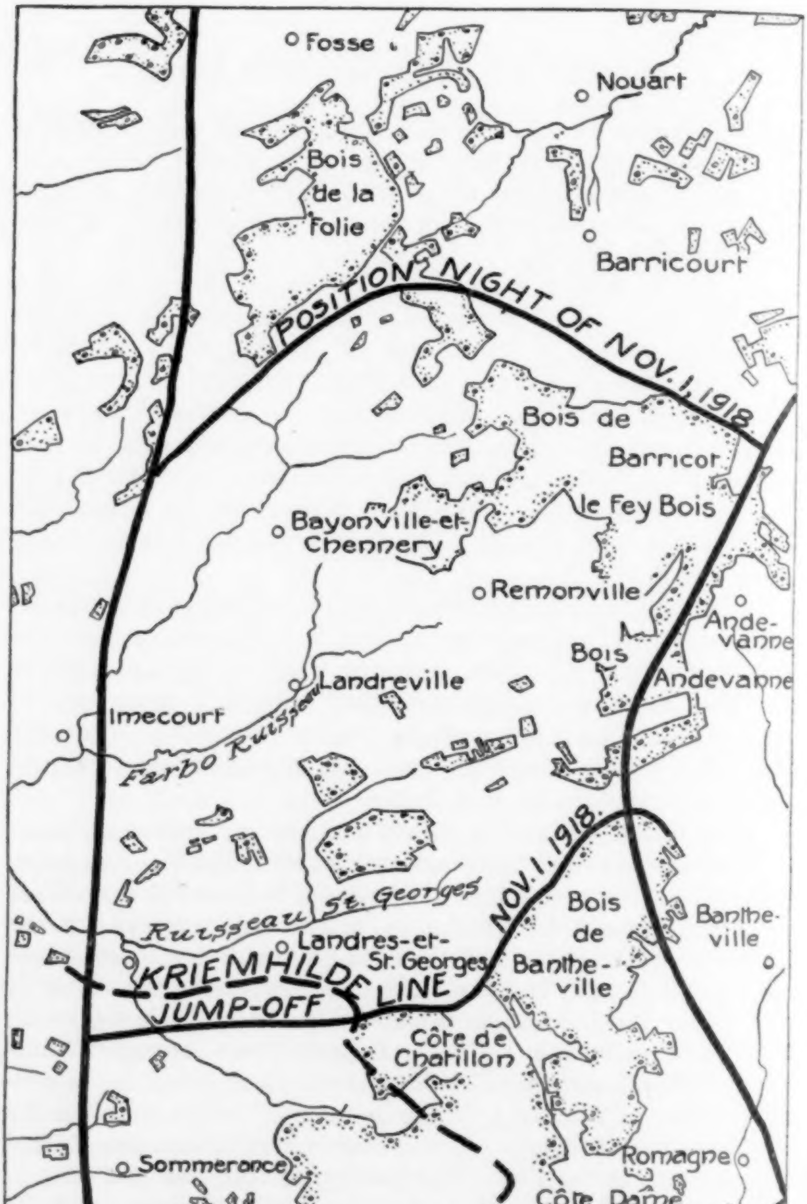


FIG. 2. ZONE OF ADVANCE OF THE 5TH ARMY CORPS IN THE ATTACK OF NOVEMBER 1, 1918.

the full depth. The Kriemhilde Stellung was then not a complete trench system but a previously selected retirement position which was rather hastily converted into a deep zone of machine gun positions and rendered very serviceable because the high hills gave good observation of our preparations for attack. Wood by wood, and hill by hill, these positions were gradually taken. By October 21, our Corps front lay in front of the wire south of Landres-et-St. Georges and thence swung northeast along the border of the Bois de Bantheville. The local and general situation being ripe, a general assault was ordered for the morning of November 1, 1918. For this successful attack most elaborate preparations were made and the maps produced by G–2, 5th Army Corps, are so complete and well designed that they are likely to become a classic example of good practice.

On the evening of October 30, Lieutenant Holmes gave me orders to prepare a report on the streams which lay in front of our positions, and which might prove an obstacle to our advance. There was no information available regarding these streams except that shown on the Plan Directeur, a map compiled by the French on the scale 1:20,000. The Water Supply Report on the area issued by the Chief Engineer gave no particulars of these minor streams. However, this seemed to be an opportunity to describe the valleys even if there was no information about the streams. The area to be covered, shown in Figure 2, lay between our jump-off line in front of Landres-et-St. Georges and the objective line along the crest of the Côte de Meuse west of Barricourt. It is 6 kilometers (5 miles) wide, and has an area of 44 square kilometers. The topographic description of a small area is difficult enough, and particularly so when direct observation can not be made. The remarks on the convexity of valley walls and on the importance of gullies were due to observations around Cheppy, and are probably the most valuable part of the paper.

With good maps on the scale of 1:20,000, and opportunity to view the country from a balloon, descriptions of this type would be rather easy to prepare. They should be useful to infantry officers to explain the maps which are now commonly furnished to them with orders to attack. Later, the same description would furnish material to the Corps Press Officer for the daily description of the terrain which he furnishes to correspondents.

Memorandum of the Water Courses and Valleys of the Zone of Advance of the 5th Army Corps

The zone of advance of the 5th Army Corps lies on the western slope of the Côte de Meuse. This striking geographical feature is a ridge which has a very steep eastern slope and a gentle western slope. It extends north as far as Verdun, and thence northwesterly, dying out in a series of low hills in the vicinity of La Chesne. The sinuous valley of the Meuse River breaks the continuity of the ridge east of the Corps Area, while the valley of la Bar River, extending from the lowlands near Buzancy north to Sedan, marks approximately its northern boundary.

The streams which drain the Côte de Meuse flow northeast and east to the Woevre Plain and Meuse River and southwest to the Aire River from a broad divide. The streams which flow northeasterly lie in sharp, steep-sided canyons and divide the eastern border of the Côte de Meuse into a series of ridges which extend like stubby fingers into the Woevre plain. The southwesterly streams are longer, have wider valleys and gentler gradients.

The divide between these two stream systems is usually flat, and from ½ to 1 kilometer wide, and generally wooded. South of Bantheville the divide lies west of the crest of the ridge; north of this point the stream divide swings northwestward and corresponds to the crest of the Côte de Meuse. In a general view only the gentle westward slope of the plateau is visible. The stream valleys are concealed. The drainage divide is only a part of the general plateau surface which slopes gently west and southwest. Occasional knobs, such as the Côte Dame Marie and the Garenne de Moulin, rise above the general level. Such knobs are usually located on the divide. Because of their steep and wooded slopes the enemy uses these knobs as strong points. They have also high value as sites for observation posts. Military operations along the wooded divide are difficult, but the history of fighting in the Bois de Gesnes, Bois de Romagne, and Bois de Chauvignon show that the divide once attained commands the lateral valleys. North of the present line the divide is marked by Bois d'Andevanne, le Fey Bois, and Bois de la Folie.

Since the eastern boundary of the Corps Area runs along the drainage divide as far as le Fey Bois, the right division will have no running water to cross except on its extreme left wing. The upper parts of Ruisseau St. Georges, and Ruisseau de

l'Agron are very small streams, and present no obstacles. The left division will cross both streams with its whole front. These streams are shallow brooks easily waded except in very wet weather. Like all the streams of the region, however, the brooks are lined with trees and bushes, and these furnish natural concealment to small bodies of men. North of Imecourt an unnamed stream flows diagonally across the field of action of the left division. It is, however, no larger than those previously mentioned, and it should be possible to cross freely from one side to the other. The bushes and trees along its banks will furnish some cover in the valley, otherwise easily commanded by fire from an enemy stationed near Bayonville et Chennery.

The succession of stream valleys which one after another cross the Corps Area present much more serious obstacles than the streams which flow in them. A brief description is therefore given. There are three important valleys: (1) The valley of Ruisseau St. Georges; (2) Valley of Ruisseau de l'Agron; (3) Valley of the unnamed stream flowing from Bayonville et Chennery to Imecourt. Each of these valleys is about 1 kilometer wide. The slopes are gentle, cleared and cultivated. The slope of the valley walls is, however, convex upward, *i.e.*, the upper part of the slope is gentle, the lower part steep. Thus it is necessary, in most cases, for an observer to come part way down the slope to see the bottom of the valley, and, vice versa, an observer in the bottom of the valley can rarely see the crest. The importance of this dead ground is obvious.

In general, the tributary valleys are mere crenulations on the valley walls, and consequently of little value. In each of the three valleys there is, however, an important exception.

In St. Georges Valley, at the town of Landres-et-St. Georges, and extending due north for a kilometer, and thence to and beyond Ferme la Bergerie, is a deep ravine. In this ravine is an enemy narrow-gauge railway. Once the heights on either side are taken, this ravine affords ready communication, free of enemy observation, to the heights dominating the valley of Ruisseau de l'Agron.

From the valley of Ruisseau de l'Agron the ravine of Farbo Ruisseau extends about 1½ km. north of Landreville. It is approximately parallel to the valley from Imecourt to Bayonville et Chennery; consequently, from the region of Imecourt and Landreville to the north our left division will be progressing with the grain of the country instead of against it. This sudden change in terrain will have proportionate effect.

The valley of the unnamed stream from Imecourt to Bayon-

ville is not essentially unlike the others. North of Bayonville et Chennery, however, it forks almost at right angles. A third ravine gives the head of this valley a fanlike arrangement of ravines. Once Bayonville is held these ravines offer excellent lines of approach against the heights from Barricot Bois to Bois de la Folie.

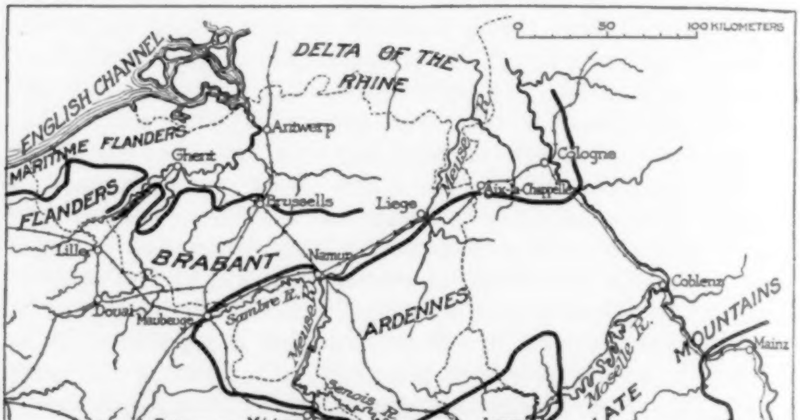


FIG. 3. MAP OF THE MAIN RAILROADS AND PHYSIOGRAPHIC PROVINCES OF THE EASTERN FRONTIER OF FRANCE.

While in general the valley walls are smooth, and the valley bottoms are grassy meadows, there are a few narrow, steep-banked gullies. These gullies are from 5 to 15 feet deep, from 10 to 50 feet broad, and from 1/16 to 3/4 of a mile long. The

gullies seem to be recent in origin and due to concentration of flood waters since the clearing of the original forests. Each gully forms a natural trench with a natural camouflage of overarching bushes. The Germans use the gullies very cleverly for machine-gun positions, artillery positions and dugouts.

Map of the Physiographic Province of Northeastern France

About the middle of October the need of a map of northeastern France on a sufficiently small scale to be studied readily when held in the hand seemed plain though no maps of this type were furnished us. Our officers were continually handicapped by the necessity of handling large maps crammed with detail of little significance for the major problems. Captain (then First Lieutenant) Thomas H. Thomas, Officer in charge of Enemy Order of Battle, requested Lieutenant Holmes to have me compile a map to show the main railway lines of northeastern France. This opportunity enabled me to make such a map and one that could also be used to show the location of the physiographic provinces. The map was made by tracing and piecing together the small maps on the scale: 1:2,000,000 which appear in the Atlas Classique de France, by Schader & Galleuedec to which reference has already been made.

The completion of this map was delayed by my being assigned to the advance echelon at Cheppy, but the lithograph was completed by November 5. While the lithographers were at work a tracing of the physiographic provinces was made in blue hectograph ink. By use of the jelly roll the boundaries of the provinces were over-printed on the black lithograph in blue. This map excited much interest among our officers, and with and without the overprint it would have been very useful if operations had continued. It is reproduced in Figure 3, redrawn so as to be reproduced in one color and to eliminate some of the crudities of the original.

Value of the Work.

To estimate the value of Intelligence Work is difficult enough, and one can not be sure that any of these efforts had any value in the final result. However, the following quotation from Colonel Russell's report on the work of G–2, 5th Army Corps in the Meuse-Argonne is typical of his generous attitude:

> Among the draughtsmen of the Topographical Section was an expert geologist, who prepared an excellent study on "The Military Topography of the Argonne Region," "A Memorandum on the Water Courses and Valleys of the Zone of Advance of the 5th Army Corps," and a "Map

of the Physiographic Provinces of the Eastern Frontier of France." This work is normally beyond the scope undertaken by the Corps, and falls more naturally under Army activities, but Private Kirk Bryan (now Second-Lieutenant Engineers) prepared the studies on his own initiative, and they were too good not to be published.[3]

PART II. SUGGESTIONS FOR THE USE OF PHYSIOGRAPHY IN THE ARMY

Reports on Topography

In the foregoing sections, the use in military operations of studies of topography has been illustrated. Many other examples could doubtless be culled from the Intelligence reports of the various armies engaged in the Great War. Future studies of this kind will fall naturally into two groups: (1) studies of large areas; (2) studies of areas of moderate or small size. Studies of large areas will partake of the general character of the report on the Argonne Region and the map of the physiographic provinces of northeastern France. Work of this type will be undertaken as a basis for strategical plans and study, or for the general information of officers and troops. It is naturally a duty of the staff of an army or the higher command in a campaign involving more than one army. Moderate-sized areas will ordinarily be involved in the sphere of an army corps. The problems will be tactical, but the occasions for making the studies may be of different sorts. In the example given in preceding pages the object was to describe a small area for the information of troops immediately before an attack. It is conceivable, however, that a detailed description illustrated by block diagrams and profiles would be of great value in solving the tactical problems of the slow reduction of an enemy position. The complicated topography of the Côte Dame Marie and adjacent hills would have furnished a fit subject for such a study.

Genetic Study of Land Forms

It is well recognized among physiographers and geographers that a complete understanding of land forms, that is, topography, can only be gained and remembered by a study of the origin of these forms. This study of genesis has led to the conception of the earth's surface as a series of repeating patterns, the patterns being identical where like rocks have been sub-

[3] Russell, Geo. M., Colonel G. S., Assistant Chief of Staff, G-2, Report of the Second Section, G. S., 5th Army Corps, U. S., Jan. 27, 1919. Intelligence Section, 5th Corps in Meuse-Argonne Operations, Ms. p. 22.

jected to like conditions for equal times. Davis has summed up this condition in the dictum: Form equals structure plus process plus stage. As a result of the application of this dictum, the trained physiographer has a classification of hills, of valleys, of shore lines, etc., imperfect enough, but sufficiently exact so that a single term calls up to his mind solid objects very complex in form, and frequently difficult to describe as individual or abstract units.

Just as he has classified single land forms, so he has divided the earth's surface into tracts of country having similar land forms or similar diversification of topography. By means of these divisions he has simplified the task of learning the characteristics of the topography of whole continents. Thus, both systematic physiography and descriptive physiography are a necessary part of the training of a professional soldier, for concise statements defining the character of the terrain form the basis for tactics and strategy. To the thoroughly trained officer operating in a region with which he is familiar, knowledge of the terrain comes easily, as part of his daily observation and map study. He hardly realizes what a large rôle it plays as a background for his thought, nor the difficulty which other men may have in acquiring the same knowledge. Thus the French had no geological officers, for a knowledge of French geology and physiography is a part of the training of every educated Frenchman, and many of their permanent officers are amateur geologists.

The American Expeditionary Force, operating in a strange country, with officers the bulk of whom were but recently civilians, needed an adequate system to supply information regarding topography, geography and geology. For engineer units, the geologic section of the Chief Engineer's Office, G. H. Q., under Lieutenant Colonel Alfred H. Brooks, supplied geologic information in a satisfactory manner. There was, however, no organized attempt to supply the army with predigested topographic information.

Peace-time Conditions

In peace time the courses in physiography in military colleges should be strengthened, and colleges which maintain a Reserve Officers' Training Corps, should make courses in physiography compulsory for men enlisted in the Corps The courses should be complete and thorough, but no special military flavor is necessary. An American army officer, even with his frequent transfers, can not be personally familiar with so great a country

as the United States. Our possessions are also quite extensive and widely scattered. The regular army officer, on transfer to a new post, should be able to quickly search out, read and understand the available physiographic literature. He will thus most rapidly obtain that grasp of the terrain which will make his military knowledge and ability most useful.

The physiographic studies of large areas here advocated will become a part of the Monographs of Military Intelligence now published by the General Staff of the Army. The studies of smaller areas will be useful in the preparation of the Zone Handbooks of the same organization.

Use of Physiographic Material in Training Periods

Knowledge along physiographic lines is rapidly being advanced. No artificial stimulus seems necessary, but areas of particular military value might be put on a preferred list by State and National Surveys. At the present time fuller knowledge of the Mexican border would be of great potential value. Prior to the outbreak of war, however, special pamphlets giving a brief but comprehensive description of the theater or probable theaters of war should be prepared from the constantly increasing body of physiographic literature. These pamphlets might well be prepared, at the request of the Army, by the United States Geological Survey. Such a plan was already on foot at the close of the war and abandoned because of the armistice. These pamphlets should be distributed to all officers and officer candidates. Judging by the popularity of D. W. Johnson's "Topography and Strategy of the War," such pamphlets would be eagerly read and studied.

As a stimulus to map reading and to the acquirements of the art of observation, short descriptions of cantonment and billeting areas are useful. These should contain simplified physiographic and geographic descriptions with accounts of local points of historic and scenic interest. They should be longer, but similar in character to the descriptions which were prepared during the late war, and printed on the backs of topographic maps of cantonment areas. Since these pamphlets would be simple compilations of existing material, and of no special value to the enemy, they should be available to all ranks.

Personnel in Active Operations

At the outbreak of war, a suitable group of geologists should be chosen for duty with the Army. It is obvious that they

should not be too old, nor more valuable at home because of expert knowledge of war minerals. The ranking officers should, however, be men of maturity and sound judgment. All the geologists in the Army should be responsible to a single officer for the technical side of their work. The geologic work done to determine suitable locations for dugouts may be equally valuable in solving a question in water supply; also, the same books and maps are necessary in preparing physiographic studies as in locating well drained sites for camps and hospitals.

Geologists with special aptitude for physiographic work while remaining under technical supervision of the Chief Geologist should be detailed to the Intelligence Section. To these officers will fall the work of preparing studies of the topography for the information of officers responsible for operations. These studies will then fall in line with other studies prepared in the Intelligence Section (G–2), and can be circulated in the same fashion.

Duties of Officers Assigned to Intelligence Section

The studies instituted by geological officers with G–2 will be of two types: (1) confidential reports to the higher command in advance of decisions, (2) general reports to lower units after decision.

Confidential reports will be dependent, for their effectiveness on the good judgment of the geologist, and he should be specially selected and of the highest caliber. He must have and retain the confidence of responsible officers, and for the best results he should have relatively high rank and should be assigned to, or be a member of the General Staff.

After decisions have been made as to the field of operations, or for offensives in large areas, reports should be sent out from Army Headquarters describing the topography, geology and other features of the terrain. These reports should be of a general character, somewhat similar to the "Military topography of the Argonne Region," but longer and with more detail. These reports should be illustrated by special maps, diagrams, and photographs, and so designed as to excite interest and to stimulate thought and observation in officers of the lower echelons. These general reports may well be followed later by special memoranda commenting on certain features of the landscape which experience has shown to have particular military importance. The illustrations for the reports will tax the ingenuity of their author, since the material should be presented in as graphic and pictorial a manner as possible.

When an offensive involving a corps or army front has been decided on, the geological officers should prepare special reports for each corps on the topography of the zone of advance. These reports should be circulated with orders to attack. They should be so written that they do not imply definite boundaries to the corps zone of advance, or define the objective, else by falling into the hands of the enemy early in the attack they give him useful knowledge. With this proviso they should be circulated down to platoon commanders. These men, in particular, should have their imagination stimulated, and visualization of the map made easy by a written description. Necessarily, they will have had less technical training than officers of higher rank, yet the platoon commanders must first penetrate into the new country. In the late war many platoon commanders went forward for five or six kilometers, with no map and no information but the order to follow a certain compass direction. A small-sized sketch map and a written description of the country are certainly not too much to give them.

The preparation of these descriptions will probably be the most difficult task of those outlined in this paper. The areas will be small. In many instances, the hills, valleys, and streams have no local names. The differences between adjacent hills may be very slight and difficult to describe. Also the audience addressed will contain men of all degrees of education with very diverse civilian occupations, and of many temperaments. All these men will be tired, worn with anxiety, restless from excitement, and many of them hungry. They will be compelled to read the statement under all conceivable conditions of discomfort and danger. It should then be short, simple, but vividly worded, and should drive home important points by repetition of simple phrases.

These descriptions for the attack should be rewritten for the Press Officers of each Corps. It is the duty of these officers to furnish daily to war correspondents a description of the country in which fighting occurs. They are usually newspaper men, and will quickly absorb and make popular the phrases which the geologist-physiographer applies to the topography. Such work has its reflex action, since an American army, from general to private, reads the daily communiqués and the accounts of war correspondents at every opportunity. If the topographic descriptions in these accounts are good then the whole army is educated, and official descriptions such as have been advocated will have proportionately greater effect.

Facilities for Geological Officers

The geological officers performing the functions outlined above will require a small working library. Through the Chief Geologist they will obtain geologic maps and reports prepared for engineering purposes. They should also have access to the maps printed and prepared by the Intelligence Section (G–2–C). They should have the complete confidence of the Intelligence Section of the unit to which they are attached, and should have the right to have special maps and diagrams prepared by this organization through which also their reports will be circulated.

Field work along the firing line will often be necessary, and the geologists should have frequent conferences with line officers of all grades. Admission to observation posts of all types should be granted them for the purpose of viewing the enemy territory. Occasional use of observation balloons and even aeroplanes may also be necessary.

GROWTH OF NEW YORK AND SUBURBS SINCE 1790

By JAMES L. BAHRET

STATISTICIAN, PUBLIC SERVICE COMMISSION, NEW YORK

THE federal government has recently finished its fourteenth census. This fact suggests a retrospect of New York's growth in population since the first federal census of 1790. In that year, the city limits embraced the entire island of Manhattan, although approximately only the area south of Canal Street was divided up into city blocks. All the rest of the island was occupied by farms with the exception of several straggling hamlets. In the course of years, as Westchester County began to be invaded with continuous rows of houses reaching out from the north bank of the Harlem River, slice after slice was split off and annexed to New York City. Finally, in 1898, with the formation of the so-called "Greater New York," the city limits were fixed as they are at present.

In order to eliminate the disturbing effect on population figures due to changes in the areas of the enumerated units, the figures in this article, for every year, have been computed, from the census reports, for the various areas as they existed at the last federal census, 1910. Thus allowance has been made for transfers of townships from county to county. The only exceptions are the several cases where a township has been split up between two counties or equivalent units. Changes in areas of units of the New York Metropolitan District subsequently to 1910 have been inconsiderable.

WHAT CONSTITUTES ECONOMIC NEW YORK AND THE METROPOLITAN DISTRICT

In the accompanying map, Economic or Industrial New York—including the Jersey portion of the great community encircling New York Bay—is bounded by the heavy continuous line, stretching in a rough half-circle from Jones' Beach, just east of Long Beach, to the Raritan River. On the east, it coincides with the eastern boundary of Nassau County. On the north and west it coincides with the outer boundaries of the cities and towns whose names are entered on the map inside the heavy boundary line. These are the limits fixed by the United

States Census Bureau for Industrial New York, which in this article I prefer to call Economic New York.

Besides the municipality of New York, the Economic metropolis embraces the entire counties of Nassau and Hudson, and parts of six others: Westchester, Bergen, Passaic, Essex, Union and Middlesex.

Outside New York City, the principal municipalities included in Economic New York, with their population according to the state census of 1915, are: Newark, 367,000; Jersey City, 271,000; Paterson, 125,000; Yonkers, 91,000; Elizabeth, 82,000; Hoboken, 68,000; Bayonne, 64,000; and Passaic city, 61,000. Thirteen additional municipalities had in 1915 over 20,000 inhabitants.

Some considerable places are just outside Economic New York, as fixed by the Census Bureau, as Plainfield, West Orange, Summit, and South Amboy. But the line had to be drawn somewhere.

But outside the limits of Economic New York tens of thousands of commuters reside. They form part of the day population of New York City. Therefore the first of the accompanying maps was drawn to show substantially all the territory within an hour by train of New York's business district. The territory shown on the map might be unified under the term "Commuter New York," or the "New York Metropolitan District."

Fairfield is the only county which lies partly outside the Metropolitan District, as delimited on the accompanying map, and represented in the following tables. Its towns are included only as far as Norwalk. But the entire counties of Westchester, Passaic, Morris, Somerset, Middlesex, and Monmouth are included, although their outer reaches are cut off on the map. Parts of Suffolk, Orange, and Mercer happen to be shown on the map, although they are here excluded from the Metropolitan District.

Some of the counties of the Metropolitan District were not in existence prior to the middle of the nineteenth century. But through our possessing census figures for the individual townships which were later combined to form the county, it is possible to arrive at the population of the present county areas decades before the organization of the counties. In the few cases where townships have at some time been split up between two counties, only approximate county figures are available for the earlier censuses. Moreover, for 1790, separate figures were never tabulated for all townships. It has therefore been necessary to divide the 1790 population of some of the counties that

lie partly within and partly without Economic New York, between the "Inner" and the "Outer" portions on the basis of the actual ratios of the "Inner" to the "Outer" population in 1800 (or even 1820, where earlier township figures are not available), taking into consideration, naturally, the actual rate

of growth of the county as a whole during the intercensal period. As none of the areas for which estimates must be made for 1790 had yet been invaded by Economic New York commuters, the hypothesis employed probably gives results not far from the unrecorded facts.

The 1915 population of southwest Fairfield has been esti-

mated on the basis of its increase from 1900 to 1910, Connecticut not having taken a state census.

POPULATION OF NEW YORK METROPOLITAN DISTRICT

Division	1790	1820	1850	1880	1910	1915
New York City	49,401	152,056	696,115	1,911,698	4,766,883	5,047,221
Manhattan	33,131	123,706	515,547	1,164,673	2,331,542	2,137,747
Bronx	1,781	2,782	8,032	51,980	430,980	615,600
Brooklyn	4,495	11,187	138,882	599,495	1,634,351	1,798,513
Queens	6,159	8,246	18,593	56,559	284,041	396,727
Richmond	3,835	6,135	15,061	38,991	85,969	98,634
Outer Ring	37,520	56,758	142,354	578,947	1,707,685	1,929,183
In New York State	13,003	18,176	28,042	70,334	229,941	296,284
Inner Westchester	3,148	4,903	9,802	36,319	146,011	179,459
Nassau	9,855	13,273	18,240	34,015	83,930	116,825
In New Jersey	24,517	38,582	114,312	508,613	1,477,744	1,632,899
Hudson County	1,944	3,137	21,822	187,944	537,231	571,371
Inner Bergen	3,282	5,276	8,903	28,037	102,493	132,786
Inner Passaic	2,066	3,338	14,275	60,748	195,992	209,790
Inner Essex	7,718	12,422	50,178	180,233	488,120	534,842
Inner Union	5,834	9,385	12,128	42,744	107,053	124,209
Inner Middlesex	3,673	5,024	7,006	8,907	46,855	59,901
TOTAL, ECONOMIC NEW YORK	86,921	208,814	838,469	2,490,645	6,474,568	6,976,404
OUTSIDE COMMUTER DISTRICT	94,967	133,373	202,188	344,983	646,531	737,379
East of Hudson River	29,014	36,777	57,674	100,974	210,500	225,409
Outer Westchester	19,519	25,573	41,533	65,880	137,044	142,254
Southwest Fairfield	9,495	11,204	16,141	35,094	73,456	83,155
West of Hudson River	65,953	96,596	144,514	244,009	436,031	511,970
Outer Bergen	6,047	9,725	5,822	8,744	35,509	45,810
Outer Passaic			8,294	8,112	19,910	26,574
Outer Essex	1,915	3,076	6,036	9,696	24,766	31,482
Outer Union	1,580	2,572	5,608	12,827	33,144	43,113
Outer Middlesex	9,445	12,818	21,629	43,379	67,571	84,815
Rockland	3,329	8,837	16,962	27,690	46,873	46,903
Morris	16,216	21,368	30,158	50,861	74,704	81,514
Somerset	12,296	16,506	19,692	27,162	38,820	44,123
Monmouth	15,125	21,694	30,313	55,538	94,734	107,636
TOTAL, METROPOLITAN DISTRICT	181,888	342,187	1,040,657	2,835,628	7,121,099	7,713,783

By "Outer Ring" in the following tables is meant the territory outside the municipality of New York, but included by the Census Bureau in Economic New York. It includes nearly all the land area within about ten miles of the city's boundaries.

MANHATTAN DECLINING

Only two instances of decrease appear in the table. Manhattan declined from 1910 to 1915, and Outer Passaic from 1850 to 1880. The latter was not actual, being due to the slicing off

of portions of townships for annexation to Paterson. But Manhattan's decline was actual, although probably not on as large a scale as the 1915 census indicates. The state's canvass of the latter year was probably not thorough. Manhattan's population will continue to decrease uninterruptedly, because nearly all its building plots are already occupied by structures, and the tearing down of dwellings to make room for commercial and manufacturing buildings goes on rapidly. The corresponding "Central Area" of London—which happens to contain approximately the same number of square miles as Manhattan—has been steadily declining in resident population since 1861.

Relative Growth of Various Divisions of the Metropolitan District

The next table of percentages of increase shows to better advantage the relative growth of the various components of the Metropolitan District.

In the case of the five Jersey counties nearest New York City, it is necessary to enter, for the growth from 1790 to 1820, the actual rate for the combined area of the present counties. In 1790, that area formed only two counties, Bergen and Essex, and township figures are not available, or else the boundaries of the townships crossed present county lines. Later, Union split off from Essex, and Hudson from Bergen, while Passaic was formed from parts of Essex and Bergen. Likewise from 1820 to 1850, it is necessary to give a combined rate for Outer Bergen and Outer Passaic. In 1820 the latter formed part of the former, and through the subsequent splitting up of townships between the two, it was not possible to compute separate figures for the two areas for 1820.

New York's Population and the Erie Canal

There is a statistical law for population aggregations of considerable size: The larger the aggregation becomes, the slower the rate of growth. A glance at the table shows that this holds true for the municipality of New York except for the period, 1820 to 1850. This violation of the statistical law, and the tremendous advance in New York City's rate of growth from 1820 to 1850 over the preceding 30-year period, is due almost entirely to the opening of the Erie Canal in 1825. On account of mountain ridges, it was not possible to connect, by canal, any other Atlantic port of the United States with the great central prairie food reservoir of the country and the rich

Per Cent. Increase

Division	1790 to 1820	1820 to 1850	1850 to 1880	1880 to 1910	1910 to 1915
New York City	208	358	175	149	6
Manhattan	273	317	126	100	D 8
Bronx	56	189	547	729	43
Brooklyn	149	1,141	332	173	10
Queens	34	125	204	402	40
Richmond	60	145	159	120	15
Outer Ring	51	151	307	195	13
In New York State	40	54	151	227	29
Inner Westchester	56	100	271	302	23
Nassau	35	37	86	147	39
In New Jersey	57	196	345	191	10
Hudson County		596	761	186	6
Inner Bergen		69	215	266	30
Inner Passaic	61	328	326	223	7
Inner Essex		304	259	171	10
Inner Union		29	252	150	16
Inner Middlesex	36	39	27	426	28
TOTAL, ECONOMIC NEW YORK	140	302	197	160	8
OUTSIDE COMMUTER DISTRICT	40	52	71	87	14
East of Hudson River	27	57	75	108	7
Outer Westchester	31	62	59	108	4
Southwest Fairfield	18	44	117	109	13
West of Hudson River	46	50	69	79	17
Outer Bergen		45	50	306	29
Outer Passaic	61		D2	145	33
Outer Essex		96	61	155	27
Outer Union		118	129	158	30
Outer Middlesex	36	69	101	56	26
Rockland	165	92	63	69	00
Morris	32	41	69	47	9
Somerset	34	19	38	43	14
Monmouth	43	40	83	70	14
TOTAL, METROPOLITAN DISTRICT	88	204	172	151	8
New York State outside Metropolitan District	306	97	30	31	6
New Jersey outside Metropolitan District	57	63	64	65	11
United States, excluding outlying possessions	145	141	116	83	—

forests of the basin of the Great Lakes. Until 1865, the Erie Canal gave New York practically a monopoly of the wholesale supply trade and the tremendous export trade in food and forest-products of this great interior basin, embracing the American half of the valley of the Great Lakes, and particularly the upper half of the Mississippi valley.

New Yorkers should not begrudge any tax burdens due to the Erie Canal. It has already contributed billions of wealth to New Yorkers——those living outside the city as well as within —and made the city's population to-day double what it would have been if the canal had never been built. The canal will contribute billions more of money to New Yorkers, and continue

to boost tremendously New York's growth in population, if the federal government can be persuaded to cease imposing freight charges upon the canal such as cripple its inherent power to draw traffic from the railroads.

Economic New York and the entire Metropolitan District do not conform to the statistical law mentioned even to the extent that the municipality does because of the effect of the city's surging population spilling over into the neighboring areas outside the city limits.

Rate Wars and New York's Growth

The decline in New York's rate of growth is far more pronounced from 1850 to 1880 than for the succeeding 30-year period. This is because unified trunk railroads over the Appalachians from the middle west to the Atlantic ports date only from 1865. Immediately the bitterest rate wars broke out between these trunk lines, and lasted almost continuously until 1880. These rate wars largely nullified New York's unique position among the Atlantic ports of the United States in possessing an all-water route and a water-level rail route to the middle west. Trunk railroads tributary to Philadelphia, Baltimore, Norfolk and Newport News, though having to climb over several mountain ridges—as compared with no mountain ridges for New York *via* the gaps in these ridges through which the Hudson and the Mohawk rivers pass—offered to carry export freight from the middle west at less than cost in order to build up their own traffic, and knock in the head the natural flow of rail-borne, as well as water-borne, commerce to New York. For Nature had favored in every way the location of our city to become the site of the metropolis and commercial capital of the Western Continent, and ultimately of the world.

As a consequence of these rate wars depriving New York of a large share of the trade that would naturally flow to it, a damper was put on New York's growth in population from 1850 to 1880, notwithstanding the vastly increased foreign immigration during that period.

Effect of Freight Differentials

And when the rate wars finally ceased, in came the Interstate Commerce Commission, and established freight rates in favor of the four ports named, so that they could fatten—grow in trade and consequently in population—at the expense of *Little Old New York.*

Although the actual cost of transporting a carload of grain from St. Louis or Chicago to one of the ports named is greater than to New York, the Interstate Commerce Commission, for more than a quarter of a century, has granted these four ports a lower rate than New York's! New York's rail distance from Chicago or St. Louis is close to one hundred miles greater than in the case of these four ports, but the route is practically all level, and even largely down grade, as compared with close to a hundred miles of heavy ascending grades for its four rivals. The time of transit to New York is less than to its rival ports.

New York's population growth has truly been phenomenal. But it would have been even greater if it were not for the differentials established by the Commission named. The federal government has in general manifested antagonism to its metropolis and greatest port. It has resorted to a number of artificial expedients to nullify New York's unique natural advantages, decentralize the nation's export trade, which Nature ordained should be concentrated at the mouth of the Hudson, and build up New York's rival ports at the latter's expense.

Richmond's Lag

The percentage table shows that Manhattan and Brooklyn's rates of growth have continuously decreased since 1850, while those of the Bronx and Queens continuously increased from 1790 to 1910. Richmond is the only borough which has, without exception up to 1910, increased at a rate below that for the city as a whole. (It should be remembered that the present divisions of the Metropolitan District have been carried back to 1790.) Richmond's rate for the past century in its entirety has been much below that of the other boroughs, as well as of the Jersey divisions of Economic New York. While Richmond surpassed the Bronx in population up until after the middle of the nineteenth century, in 1915 it contained less than one sixth as many inhabitants. Though much nearer New York's business center in miles, its insular position and lack of rapid transit have caused it to fall hopelessly behind.

Effects of Invention of Steamboat

The most notable increase in the percentage table, that of Brooklyn from 1820 to 1850 (1,141 per cent.) was due to the displacement of rowing and horse-treadmill ferries by steam ferries about 1810. New York business men refused to make their homes across the narrow East River in Brooklyn until the

advent of the steam ferry set at nought the rapid current of that tidal stream.

Effects of Rapid Transit

Two of the other most remarkable increases are those of the Bronx from 1850 to 1880 (547 per cent.), due to its invasion by the east-side elevated railway, and from 1880 to 1910 (729 per cent.), due to the opening of the first elevated extensions of the Interborough subway.

New York City (present area) increased much more rapidly than its Outer Ring up to 1850. Since that year this relation has been reversed, owing primarily to vast improvement in facilities for getting to the west of the Hudson, first steam ferries displacing treadmill and sailboat ferries, and later tunnels in large part displacing steam ferries. A factor almost equally important was the later vast improvement in train service, which lured many New York business men to establish their residences in the Outer Ring.

Up to 1910, Economic New York increased far more rapidly than the Outside Commuter District. Since that year, conditions have been for the first time reversed.

New York state and New Jersey outside the Metropolitan District have increased far less rapidly than the District.

Three States Benefit by the Port of New York

The percentages of the population of the Metropolitan District residing in the different states have been as follows:

Economic New York

	1790	1820	1850	1880	1910	1915
New York State	72	82	86	80	77	77
New Jersey	28	18	14	20	23	23

Entire Metropolitan District

	1790	1820	1850	1880	1910	1915
New York State	47	60	75	73	73	72
New Jersey	48	37	23	26	26	27
Connecticut	5	3	2	1	1	1

New Jersey's proportion steadily declined until 1850. Since that date it has been on the increase. As already indicated, the reason for the change in trend is the vast improvement since 1850 in facilities for getting west of the Hudson.

New York's Rival Metropolises

There is next presented the population growth of all other metropolises of the world having more than 1,500,000 inhabitants in 1910. But Petrograd is omitted because its published population has rarely been the result of an actual count. During the entire existence of the city, only two or three censuses have been taken. But particularly, its population has dwindled to less than a million as a result of the World War.

For Tokio prior to 1880, only estimates by Japanese statisticians are available. After 1850, Tokio became semi-depopulated because it ceased to be Japan's capital. When restored as the capital, it more than recovered its lost ground.

In cases where the censuses of foreign metropolises were taken in different years from those of the United States census, the population figures have been synchronized on the assumption of a uniform annual increase during the intercensal period.

Population of New York's Rival Metropolises

City	1790	1820	1850	1880	1910
Greater London	884,000	1,569,000	2,636,000	4,679,000	7,184,000
Paris	448,000	749,000	1,350,000	2,213,000	2,867,000
Chicago	....	....	30,000	503,000	2,185,000
Berlin	151,000	226,000	454,000	1,122,000	2,071,000
Tokyo	1,000,000	1,500,000	1,500,000	858,000	2,062,000
Vienna	219,000	260,000	425,000	1,137,000	2,031,000
Philadelphia	29,000	64,000	409,000	847,000	1,549,000

Per Cent. Increase

	1790 to 1820	1820 to 1850	1850 to 1880	1880 to 1910
Greater London	77	68	78	54
Paris	67	80	64	30
Chicago	..	..	1,576	334
Berlin	50	101	147	85
Tokyo	50	00	D 43	140
Vienna	19	63	168	79
Philadelphia	121	539	107	83

Chicago and New York

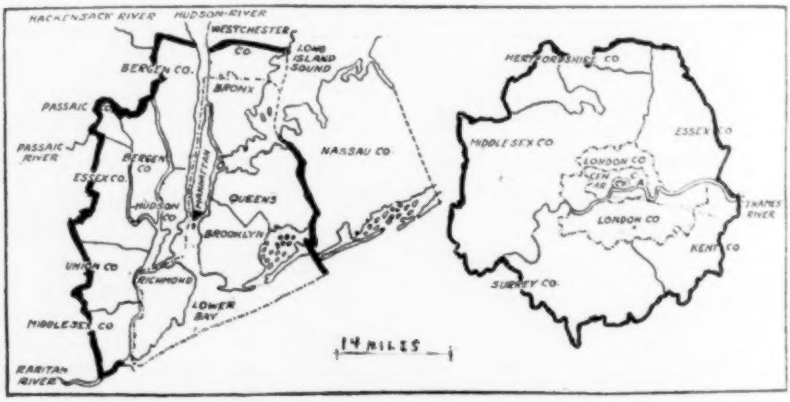
The only metropolis of the world that has threatened to overtake New York is Chicago. Her phenomenal increase from 1850 to 1900 truly scared the lovers and partisans of *Little Old New York.* We did not want ultimately to be compelled "to go way back and sit down." We were on the anxious seat until the 1910 census returns were published. These showed an increase

for *Economic Chicago* for the decade just ended of 33 per cent., as compared with *Economic New York's* 41. Hurrah again for *Little Old New York!* She can't be beaten in the long run. By 1910, Chicago had shot her arrow and fallen short of the mark, so ardently striven for by her business men, of the premiership among not only America's but the world's cities.

New York and London

But a still greater triumph fell to *Little Old New York* only three years ago. And few New Yorkers have as yet heard of it. They have been ignorant of the fact that since 1917 they have been living not only in the largest city in the world, but the largest this planet has ever seen.

There has been much dispute in various publications as to whether New York or London is to-day the largest population aggregation in the world. To settle the question definitely, the writer has taken the trouble to compute from the census returns for the two metropolises their population living on approximately equal land areas, the only fair basis for a comparison. Political boundaries form an entirely artificial basis.



Economic New York: New York City embracing the boroughs of Manhattan, The Bronx, Brooklyn, Queens and Richmond; Outer Ring embracing Hudson County entire, and parts of Westchester, Bergen, Passaic, Essex, Union and Middlesex. Manhattan south of Fulton Street (shaded) corresponds to London "city" (Cy.). The Census Bureau includes Nassau, but this county is here omitted in order to make the two areas approximately equal.

Metropolitan Police District of London: Embracing the entire counties of London and Middlesex and parts of Hertfordshire, Essex, Surrey and Kent.

Moreover, it is not generally known that the population of London, as usually published, is not for any political entity. It is the combined population of numerous cities, boroughs, and

towns lying within a radius of eighteen miles—roughly speaking—of the center of London Bridge. Just as Economic New York, as delimited by the federal Census Bureau, is an aggregation of cities, boroughs, and towns.

Some pseudo-statisticians, in their defense of London, have taken Economic London on both sides of the Thames to compare with only that portion of Economic New York which lies on one side of the Hudson!

London and its suburbs happen to have a unified police administration, just as New York did half a century ago, but soon abandoned. The population "of London" generally published is for its Metropolitan Police District. The correponding area for us Knickerbockers is Economic New York. But the limits established by the Census Bureau make Economic New York cover 271 more land square miles than does the Metropolitan Police District of London. In order to make the areas approximately equal, I have omitted Nassau County entire from the comparison, because it is the least densely populated large section of Economic New York. This omission gives London the advantage over New York by 3 land square miles. Further, Economic New York, exclusive of Nassau, contains to-day 95 square miles of uninhabitable salt marsh, while London contains practically no uninhabitable land. This gives London an additional considerable advantage in the comparison—at least ten per cent.

I have computed from the census reports for the two areas described the records, since the beginning of the nineteenth century, of the two contestants in the race for the premiership among the cities of the world.

GROWTH OF THE METROPOLITAN POLICE DISTRICT OF LONDON
(693 LAND SQ. MI.)

Census Year	County of London		Outer Ring		Total, Metropolitan Police District	
	Population	Per Cent. Inc.	Population	Per Cent. Inc.	Population	Per Cent. Inc.
1801	959,310	—	155,334	—	1,114,644	—
1811	1,139,355	18.4	184,544	18.4	1,323,899	18.4
1821	1,379,543	21.1	216,808	17.5	1,596,351	20.6
1831	1,655,582	20.0	247,990	14.4	1,903,572	19.2
1841	1,949,277	17.7	286,067	15.4	2,235,344	17.4
1851	2,363,341	21.6	317,594	11.2	2,680,935	20.3
1861	2,808,494	18.8	414,226	30.4	3,222,720	20.2
1871	3,261,396	16.2	624,245	50.8	3,885,641	20.6
1881	3,830,297	17.4	936,364	50.0	4,766,661	22.7
1891	4.227,954	10.4	1,405,852	50.1	5,633,806	18.2
1901	4,536,267	7.3	2,045,135	45.5	6,581,402	16.8
1911	4,521,685	D0.3	2,729,673	33.5	7,251,358	10.2

On the basis of the annual increase during the latest intercensal period, I have computed the following estimates:

Growth of Economic New York (Excl. of Nassau) (690 Land Sq. Mi.)

Census	Present Limits of New York City		Outer Ring (Excl. Nassau)		Total Economic New York (Excl. Nassau)	
	Population	Per Cent. Inc.	Population	Per Cent. Inc.	Population	Per Cent. Inc.
1800	79,216	—	—	—	—	—
1810	119,734	51.1	—	—	—	—
1820	152,056	27.0	43,485	—	195,541	—
1830	242,278	59.3	56,227	29.3	298,505	52.7
1840	391,114	61.4	78,451	39.5	469,565	57.3
1850	696,115	78.0	124,114	58.2	820,229	74.7
1860	1,174,779	68.8	241,632	94.7	1,416,411	72.7
1870	1,478,103	25.8	396,633	64.1	1,874,736	32.4
1880	1,911,698	29.3	544,932	37.4	2,456,630	31.0
1890	2,507,414	31.2	780,089	43.2	3,287,503	33.8
1900	3,437,202	37.1	1,115,154	43.0	4,552,356	38.5
1910	4,766,883	38.7	1,623,755	45.6	6,390,638	40.4

Year	County of London	Outer Ring	Total, London Metropolitan Police District
1915	4,515,853	3,003,489	7,519,342
1916	4,514,395	3,071,943	7,586,338
1917	4,512,937	3,140,397	7,653,334
1918	4,511,479	3,208,851	7,720,330
1919	4,510,021	3,277,305	7,787,326
1920	4,508,563	3,345,759	7,854,322

Year	New York City	Outer Ring (Excl. Nassau)	Total, Economic New York (Excl. Nassau)
1915	5,431,723	1,878,055	7,309,778
1916	5,564,691	1,928,915	7,493,606
1917	5,697,659	1,979,775	7,677,434
1918	5,830,627	2,030,635	7,861,262
1919	5,963,595	2,081,495	8,045,090
1920	6,096,563	2,132,355	8,228,918

There is hardly room for the slightest doubt that New York, at the latest in 1920, has overtaken London, on the basis of equal land areas. Both cities were hard hit by the war, and thus the actual population increase of both, subsequently to its outbreak, will probably be found, when the returns of the forthcoming censuses are tabulated, to lag considerably behind what would be expected on the basis of the growth during the first decade of the twentieth century. But London was immeasurably harder hit by the war than was New York, and her growth in population has almost certainly been retarded the more.

SHALL THE METROPOLITAN DISTRICT ENTER THE UNION AS A SEPARATE STATE?

This winter two bills have been introduced in the state legislature having as their object to set off New York City, together with several of the near-by counties of the state, as a separate member of the federal Union. If the metropolis and suburbs should ever enter the Union as a separate state, it should include, for both economic and political reasons, the commuter areas of New Jersey and Connecticut, as well as those of New York state. Particularly the development of port facilities lags because of the divided state jurisdiction. But this great defect will probably be remedied in a few years by the recently organized New York-New Jersey Port and Harbor Development Commission.

If the Metropolitan District, as delimited in this article, should become a separate state, its present New York state and New Jersey inhabitants, respectively, would no longer be burdened with paying the vast bulk of the state taxes of both commonwealths. But just because Economic New York is compelled to play "Lady Bountiful" to the outside areas of the two states, the latter's representatives in the state legislatures would never consent to a separation. On the other hand, the legislators from the Metropolitan District might be able ultimately to outvote the more or less rural Solons. In 1915, 57 per cent. of New York state's population resided in the Metropolitan District, and 74 per cent. of New Jersey's.

There is the sentimental reason that the splitting up of New York state would cause the latter to lose its primacy among the states in population, wealth and manufactures. New York has enjoyed the distinction of being the "Empire State," beginning with 1820.

If the Metropolitan District had been a separate state in 1910 (the year of the latest published federal census returns), it would have been exceeded in population by only one state, Pennsylvania, which then had 7,665,000 inhabitants, as compared with the Metropolitan District's 7,121,000. The remainder of New York state, with close to its present area, would have had a population of only 3,933,000, and ranked fourth among the states. The population of the remnant of New Jersey, although still including the vast bulk of its area, would have been only 670,000. Instead of eleventh rank among the states, New Jersey would have dropped to thirty-sixth.

But in 1929 the new state of "South New York" (as it would

be logically named, rather than "Manhattan" or "Greater New York," as proposed in the two bills before the legislature) would itself become the Empire State, since its estimated population, on the basis of growth from 1880 to 1910, would then be 9,838,-000, as compared with Pennsylvania's 9,812,000.

But there are also material objections to the Metropolitan District's becoming a separate state. Things that happen up-state, such as the building of canals, railways, aqueducts, automobile roads, the regulation of dairy farms, etc., possess a vital interest for Gothamites, and have a marked bearing on the latter's health and happiness and chase for the "almighty dollar." It is very desirable that Gothamites retain their "say," and particularly their votes, in the transactions in Albany's legislative halls.

EDUCATION AND LEARNING IN AMERICA

By Professor ARTHUR GORDON WEBSTER
CLARK UNIVERSITY

IT is well known that we in the United States spend more upon education than any other country. What do we get for it? Are the returns in any way commensurate with the enormous sums expended? Does the number of institutions calling themselves colleges and universities to the neighborhood of perhaps 400 insure us and the community that it has the highest standards of learning or even appreciates it? I think there is no doubt that the answer to this question will be in the negative. We have been accustomed to flatter ourselves that the common schools are an American invention. We have no peasants in this country and we think that the average of education and intelligence is very high. And yet we find as a result of the psychological tests made upon about three million men in our Army that the average mental age of the soldier was about 13½ years. The officers were very good, it is true, but were chosen to a large degree from persons who had had the advantage of a college education. To that extent it is creditable to the colleges. But we have still to examine the question of the efficiency of the work of the colleges.

Last summer, while on a mission to France, largely educational in character, I was frequently at the Sorbonne. I found in passing through the great court of the new Sorbonne one day that it was full of young persons of the two sexes, and to my question, "Qui sont ces bébés?" the reply was made, "C'est pour le baccalauréat." There were young girls with curls down their back and I saw one boy with bare knees in the uniform of a boy scout. One must remember that the "baccalauréat" corresponds not merely to the finishing of the high school, but to perhaps the first two years of college, and you can imagine my astonishment. I said, "And will these boys be prepared for the Ecole Polytechnique [a school of the standard which I regard as the highest in the world] in four years?" "They will be ready in three years, monsieur." Let us remember that the Polytechnique is the school open to intending officers who have passed an extremely drastic examination for entrance. A friend of mine, Général Ferrié, who is in command of all the

French army telegraphs, told me that in the year he was admitted, out of 1,200 candidates 200 were admitted. Ask yourself whether there is any school in the United States of which merely to be a member is a distinguished honor, or which imposes for its membership any such qualification, and I have no doubt as to the answer.

In a recent newspaper President Eliot is quoted as attacking West Point. And the paper the next day says that it is proposed that a resolution be introduced into Congress to examine the curriculum. It is not the curriculum at West Point that needs examination. It is something far deeper.

In an article written by a professor in last December's *Atlantic Monthly* is an extremely good picture of a faculty meeting and its futility. Everybody is bored. No one can make a decision. Nothing is accomplished. Everybody goes away disgusted. I have seen such faculty meetings and I have seen such professors. Fortunately I do not belong to one. My thirty years have been thirty years of almost unmitigated pleasure and enjoyment, full of the joy of living, and marred only by th difficulty of making both ends meet and of finding the money either to finance my department or to get along with the small appropriations that have been available. But sweet are the uses of adversity (and university). I have learned to do it.

A few months ago, at a meeting of the American Academy of Arts and Sciences in Boston, I was accosted by a friend, one of the most learned of the members of the Harvard faculty, with the exclamation, "Well, Webster, I suppose you are not ashamed of being a professor as I am." "No," said I, "I am proud of it. What is the matter?" He replied, "I sat all yesterday afternoon in a faculty meeting discussing whether the football team, which had accomplished very little in an intellectual way during the last few months, should be allowed to go to Pasadena to give a gladiatorial show, and we decided that it should not. What was my disgust to read in the morning paper that the team was going!" When I heard this statement I wrote an article commenting on it to the *Harvard Alumni Bulletin*, stating that I should withdraw the modest subscription that I had made toward the fifteen million dollar fund. I said that inasmuch as no self-respecting person would wish to be a professor at Harvard it would be unnecessary to have a fund to raise their salaries. The letter has as yet drawn forth no comment.

Some dozen years ago the Nobel Prize of about forty thousand dollars was awarded to Professor A. A. Michelson, the great physicist of the University of Chicago and my predecessor

where I am. His colleagues at that institution were so delighted that they prepared to honor him by giving a banquet to which scientists in all parts of the country were invited. I was much pleased to be included and should certainly have gone had limitations of time and money not prevented. Later on, the same prize came to Professor Theodore W. Richards, the distinguished chemist of Harvard. Meeting him one day, I said, "Richards, what did they do for you in Cambridge?" "Do for me?" said he, seeming to misunderstand the import of my question. "I had some very nice notes." "Do you mean," said I, "that they did nothing in public to show the appreciation of the honor which you had received?" "No," said he. Whether this is characteristic of the difference between the effete East and the hustling, wide-awake Middle West I do not know. I merely know that when the victorious football team referred to returned from Pasadena it was given a banquet to show the distinguished honor in which the citizens of the intellectual community of Boston and Harvard held it.

Such stories as these are but symptoms. They are straws to show which way the wind blows. They would be possible in no other country than the United States. To be sure, we are a democracy. We believe that all men are *created equal.* There may be some who believe that men stay equal and there may be some who wish them to stay equal. I am not one of that number. We do not wear silk buttons on our coats, nor do we as a rule attach letters to our names. We do not become privy counselors, "wirkliche" or other, and we eschew all apparent marks of distinction. Sometimes we form exclusive societies to which we select a supposedly learned élite. It is cruelly said by outsiders, and sometimes by insiders, that the chief purpose of getting into such societies is to keep others out. However, this I do not wish to discuss.

Now, what is the reason for this state of affairs? It is frequently said that it is because the country is new. How new is it? If I am not mistaken, the United States is the oldest republic in the world, with the exception of San Marino and Andorra. For considerably over a century we have had a large measure of political freedom and an unexampled degree of prosperity. Ever since the close of the Civil War, with rare exceptions, we have had such a degree of prosperity that it has been possible for almost everybody to have a college education, with the result that our educational institutions are full of the most mediocre intellects, persons who, in the words of our Atlantic professor, really ought to be plumbers or something of an even less intellectual status.

A college is looked upon, according to the statement of Professor Lightner Witmer, of the University of Pennsylvania, at a meeting of the American Philosophical Society, as a country club somewhat marred by attendance at recitations. Many of the colleges are no more than schools of a somewhat superior grade, and it is very noticeable that students and even professors coming from the South and West almost uniformly refer to the college as a school. And the phrase, "When will school open?" is most familiar.

The young man writing the prize essay on Harvard is frankly of the opinion that the so-called men at Harvard are treated like school boys, that facts are poured into them, that only their memory is made use of, that they are not taught to think and reason for themselves. The trouble again, in my opinion, is not with the institution, the system, the professors, but with the community. When going to college is looked upon as the culmination of a social career or preparation for the same, when the boy or girl can say, "I don't have to work; father will pay," it is a sign that something is wrong with the community. When the woman who comes in to do the washing asks the head of the family what her husband does and she says, "He is a minister," and the washerwoman says, "Oh, of course, I don't blame him; he has got to do something," as I heard told recently, it is very obvious that something is wrong.

In this country the only criterion of success is the amount of money that a person has made. Two years ago, having done a little profiteering, I bought a modest automobile. One day when I was taking a young lady, a friend of my daughter's, out to drive, I said to her. "People think much more of me now that I have an automobile." "Oh, yes, Dr. Webster," she responded. This was a graduate of one of our leading colleges for women, a very bright young woman indeed. And yet she immediately fell for my jocular remark.

How is it that boys and girls of fifteen and sixteen in France can pass the examinations for entrance at the Sorbonne? Are they brighter than our boys and girls? No. But they look upon education as a serious business. They look upon an educated man as a superior person. They consider the chief aim of man not to be the accumulation of a certain number of millions of francs, but the accomplishment of some creative task. In Paris it is not the fat profiteers riding about in limousines who attract the attention of the people. It is the members of the Institut, the great men of literature, science or art. Rightly does Paris call herself "la ville Lumière." France is still "la grande

nation." After a residence of any length of time in Paris, how tame seems life in the most attractive American city!

Last summer I visited by far the greater majority of the universities in France. I found the laboratories extremely meager, often in dark rooms, in old-fashioned buildings, the equipment very limited. But the spirit was splendid. Not in vain have fellowships for Americans going to French universities been founded, for there shall they find the true spirit of learning. At Nancy I was personally conducted by the rector over the university and adjacent parts of the city. He took me to the Lycée Henri Poincaré. Before the door stood a bronze statue of the great mathematician, probably the greatest intellect of the latter half of the nineteenth century. We passed into the court. "Ce n'est pas gai," said the director. No, it is not gay. The life of the French *lycéen* is slavery. Immured within the walls of the school, he is seldom let out except under the surveillance of an instructor. His life is extremely dreary. But they produce the goods. They do not go out for the team; they do not go out for the crew, or for the paper, or for the Glee Club, or for the theatrical profession. They go *in* for study and hard labor. They consider that learning is an end in itself and are not continually asking, "Why do I *hafter* do this?" The only thing that father wants is that his son shall become a distinguished man.

The trouble with education in the United States is with the community, with the fathers and mothers, who do not insist that their children shall do anything that requires exactitude, stick to it and not let up until they get it done. A few days ago my assistant in the laboratory was doing some computation with the calculating machine. I said to him, "It is a shame that you should be turning that coffee-mill; we ought to be able to get some boy from the college to do it." I inquired of the college professor of mathematics. He said, "There is not much use, because nobody now learns to do anything carefully and get an exact result." If a boy multiplies two by three and gets five, of course that is pretty near, it is the next number, but that is hardly what we want. Colleges have again and again changed their standard, making more and more subjects elective, until now nobody has to do anything that is very difficult simply for the purpose of training the mind, and I regret to say that psychologists have done more to spread the idea that there is no subject that trains the mind for anything else, an opinion which I do not hold in the slightest. If I had my way, no one should graduate from college unless he knew at least what the infini-

tesimal calculus was and what it was for, what relation its invention bore to the history of thought in general, and a few matters of similar import which should be a part of the intellectual equipment of every educated adult. But boys in college are not adults. I sometimes wonder whether "old grads" are adults, either. I have recently heard the opinion expressed that without alcoholic stimulant it will be impossible to hold reunions at Commencement. When I once protested at being regaled at a meeting of a local Harvard Club with a talk by a football coach on the maneuvers of that interesting game, I was asked what other subject there was which was of common interest to college graduates. I replied that in that case I thought the colleges should close.

If we turn to the Army and Navy the case is even worse. The criticisms made by President Eliot on West Point are eminently sound. We have at any rate at the top of our colleges a number of universities where the élite students may engage in graduate work and where much of the work done is of first quality. A very large amount of scientific research is now done in the United States, much of it comparing very well with work that is done anywhere else. But in the Army and Navy we have nothing of the sort. Boys are admitted to West Point or Annapolis, for I shall speak of the two on like footing, who have the merest fragment of elementary education, and in four years they are supposed to be turned out complete officers and gentlemen. If it is considered that part of their course consists of so much mathematics as to take them through the elements of the calculus, it may easily be guessed how deep this knowledge must be.

Within the last few years I have personally visited both the Naval Academy at Annapolis and the Military Academy at West Point, and during the five years of my membership in that at first much over-advertised and lately too much forgotten institution the Naval Consulting Board of the United States I have had the opportunity of meeting many officers of both services. These officers are always extremely agreeable gentlemen, accustomed to the handling of men and thoroughly competent in the ordinary duties of their stations. They are all alike in one thing, however. They have been deprived of the opportunities of a really superior education. Army and Naval officers do not as a rule originate ideas, nor do they contribute to the advancement of science even in their own professions. In France, Germany or Italy it is no rarity to see shoulder straps at scientific meetings. In the United States it is almost un-

heard of. I do not need to mention Napoleon's general Monge who invented the science of descriptive geometry, or Poncelet, who while confined in a Russian prison discovered the projective properties of figures. A long line of French and Italian officers have contributed advances not only to mathematics, but to many of the other sciences. I speak of mathematics, being one of the most difficult, first.

The contribution of the Ecole Polytechnique to the winning of the war was enormous. A French general said to me, "*Sans la Polytechnique, nous ne l'eussions pas fait.*" It was noticeable that during the war it was necessary to call in a large body of professors of mathematics, physics, chemistry, to say nothing of psychology and other subjects, from the universities. These supposedly cloistered individuals contributed in very large measure to the winning of the war, many of them working their galvanometers and other laboratory instruments under German shell fire at the front and winning distinguished honors for so doing. Even the regular Army and Navy were grateful. As one concrete result a number of positions were created in the Army Ordnance Department which were filled by mathematicians, physicists or engineers from civil life.

During my visit to Annapolis, where I was received with the greatest hospitality by the superintendent, who personally conducted me all over the school, when we came to the physical laboratory, as I am a physicist I asked some questions of the young instructor in order to show my interest. He regretted that he was unable to answer; excusing himself because he had but recently come. That night at dinner I could not resist asking the superintendent, who told me that he had brought these officers with him, whether he could make a physicist out of any officer. "Oh," he replied, "they had very distinguished records at sea." I had nothing to say, but it occurred to me that no amount of distinction at sea would have made a physicist of me.

In the Army and Navy the theory is that anybody can teach anything if ordered to. Of such a theory the less said the better. It is high time that this country had a college in which a few élite officers of both the Army and Navy could study together the superior portions of the technical branches of their subjects. They should have as professors the most distinguished scientific men that the country can afford. They need not necessarily wear chickens on their shoulders. It is high time that the feeling of self-sufficiency which impregnates officers of the regular military establishments should be somewhat dissipated. They may as well learn that occasionally a person

not in uniform can give them some advice. It is not so many years ago that a committee from West Point visited the leading colleges of the country and on returning to West Point made the report that they had learned nothing and saw nothing to change. It is to be hoped that the large number of officers who went to Europe during the war and mingled with the officers of other armies may have had their eyes somewhat opened. But, as far as I can learn, the great majority not only of the doughboys, but even of the officers, made no attempt to learn French and did not find out very much about the differences in French ways of education from ours. Still they undoubtedly learned something.

What suggestions can now be made of a positive character for the amelioration of a condition that must shock all those who actually learn the truth? In the first place, the removal of our self-satisfaction. We are not the best educated nation in the world. We do not produce the most original ideas in learning or in invention. We are, to be sure, extremely quick and facile, and that is one of our weaknesses. It is easy to leave a thing until the necessity arises, and then to jump at it and do it. In that way the war was won. But in the case of another war, which God forbid, we shall have many of the things to do over in the same slipshod and backward way. Secondly, we must dispel the illusion that the chief thing in life is to have a good time, an expression which, as I recently heard a charming young Frenchwoman say in a lecture, does not exist in French. Youth is the time for work; youth is the time for beginning to learn. But manhood is the time for the appreciation of learning, for the appreciation of the fact that learning is the chief thing that distinguishes the upper classes from any other classes, that learning has a value of its own and is, like virtue, its own reward. We must improve our elementary schools which are now in dire danger of extinction through the wretched rewards paid, insufficient to attract competent teachers. These schools never were good enough and now bid fair soon to fall almost to zero level. Of course, we hope the times will soon change and compensations return to something like normal. That is not enough. There is no reason that our children should not be as thorough as French children or that graduates of our colleges should not be able to pass the examinations formerly set for Rhodes scholars.

In my opinion it will be necessary to relegate the colleges to the rank of schools and to actually limit the number of people who go to them. The insane desire to increase and in-

crease the size of our colleges must be replaced by a desire to increase the quality even at the expense of numbers. What place in civilization can be attributed to a State which does not realize that the education of its citizens is of supreme importance to the State, and that allows education to be supported by drives to squeeze from the unwilling pockets of graduates of private institutions a sum sufficient to enable their professors to maintain their self-respect?

In a late number of the *Weekly Review* is a letter from the dean of a university of the Middle West. In it he insists upon the importance of the knowledge at headquarters of the number of hours spent by every professor in the classroom and of the number of students there are associated with each professor and with each classroom. I have been expecting this for some time and we shall be called upon to punch clocks.

To my great good fortune I have not spent my life in any such atmosphere. I have been so fortunate as to belong to an institution modelled upon the great institutions abroad in which learning, and particularly scientific learning, was looked upon as the chief desideratum and where research was made the chief object in view. Every member of the instructing staff was stimulated to produce all that he could and to convey the same feeling to every one with whom he came in contact. No one ever came to Clark University unless he wished to become a scholar, unless he thought that he could contribute something to the great structure of human learning.

We hear much in these days of research councils, of organizations of research, of cooperation, of organization, of efficiency, of questionnaires, and of red tape. I hear yet of no corporations for the cooperative production of poetry, of music, of sculpture or of painting. Of course the pupils of Rubens did cooperate in painting so many miles of naked Dutch women, but I suppose it was under the immediate stimulation and supervision of the master, and so it is possible to carry on research. Research is not a matter of bureaus, but of enthusiasm. There is no teacher so good, so stimulating, so productive of enthusiasm as the man who himself is a great contributor to learning.

In my trip last summer I had the good fortune to make the acquaintance of Professor Paul Sabatier, of the University of Toulouse, who has received the Nobel Prize in chemistry and was looked upon, as was perfectly evident, by all his colleagues as the chief adornment of that flourishing university. Even then there was being constructed for him a new laboratory to

accommodate those students whose influx there was due not to athletic prowess, or pride of age, or great buildings or marble palaces, but to the reputation of the master.

When such a spirit as this prevails in all universities of the United States, when professors do not have to act as policemen or judges to portion out punishments and rewards and to spend their time in doing things that are of no importance to the community whatever, when learning is looked upon as a sufficient motive for engaging the attention of the best intellects, and when those financial resources, which we command in a degree unparalleled in the history of the known world, have been devoted to this cause, and when it is thought better to invest twenty million of dollars in laboratories rather than in one battleship devoted exclusively to purposes of destruction, then possibly we may see the United States take the position that her material success entitles her to take among the great nations of the world.

THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE[1]

FOSSILS AND LIFE

By Dr. F. A. BATHER

PRESIDENT OF THE GEOLOGICAL SECTION

FOR many a long year the relatively simple mechanics of the vertebrate skeleton have been studied by paleontologists and anatomists generally, and have been brought into discussions on the effect of use. The investigation of the mechanical conditions controlling the growth of organisms has recently been raised to a higher plane by Professor D'Arcy Thompson's suggestive book on "Growth and Form." These studies, however, have usually considered the structure of an animal as an isolated machine. We have to realize that an organism should be studied in relation to the whole of its environment, and here form comes in as distinct from structure. That mode of expression, though loose and purely relative, will be generally understood. By "form" one means those adaptations to the surrounding medium, to food, to the mode of motion, and so forth, which may vary with outer conditions while the fundamental structure persists. Though all structures may, conceivably, have originated as such adaptations, those which we call "form" are, as a rule, of later origin. Similar adaptive forms are found in organisms of diverse structure, and produce those similarities which we know as "convergence." To take but one simple instance from the relations of organisms to gravity. A stalked echinoderm naturally grows upright, like a flower, with radiate symmetry. But in the late Ordovician and in Silurian rocks are many in which the body has a curiously flattened leaf-like shape, in which the two faces are distinct, but the two sides alike, and in which this effect is often enhanced by paired outgrowths corresponding in shape if not in structure. Expansion of this kind implies a position parallel to the earth's surface, *i.e.*, at right angles to gravity. The leaf-like form and the balancers are adaptations to this unusual position. Recognition of this enables us to interpret the peculiar features of each genus, to separate the adaptive form from the modified struc-

[1] Extracts from addresses given at the Cardiff Meeting.

ture, and to perceive that many genera outwardly similar are really of quite different origin.

Until we understand the principles governing these and other adaptations—irrespective of the systematic position of the creatures in which they appear—we can not make adequate reconstructions of our fossils, we can not draw correct inferences as to their mode of life, and we can not distinguish the adaptive from the fundamental characters. No doubt many of us, whether paleontologists or neontologists, have long recognized the truth in a general way, and have attempted to describe our material—whether in stone or in alcohol—as living creatures; and not as isolated specimens but as integral portions of a mobile world. It is, however, chiefly to Louis Dollo that we owe the suggestion and the example of approaching animals primarily from the side of the environment, and of studying adaptations as such. The analysis of adaptations in those cases where the stimulus can be recognized and correlated with its reaction (as in progression through different media or over different surfaces) affords sure ground for inferences concerning similar forms of whose life-conditions we are ignorant. Thus Othenio Abel (1916) has analyzed the evidence as to the living squids and cuttle-fish and has applied it to the belemnites and allied fossils with novel and interesting results. But from such analyses there have been drawn wider conclusions pointing to further extension of the study. It was soon seen that adaptations did not come to perfection all at once, but that harmonization was gradual, and that some species had progressed further than others. But it by no means follows that these represent chains of descent. The adaptations of all the organs must be considered, and one seriation checked by another. Thus in 1890, in sketching the probable history of certain crinoids, I pointed out that the seriation due to the migration of the anal plates must be checked by the seriation due to the elaboration of arm-structure, and so on.

In applying these principles we are greatly helped by Dollo's thesis of the Irreversibility of Evolution. It is not necessary to regard this as an absolute Law, subject to no conceivable exception. It is a simple statement of the facts as hitherto observed, and may be expressed thus:

1. In the course of race-history an organism never returns exactly to its former state, even if placed in conditions of existence identical with those through which it has previously passed. Thus, if through adaptation to a new mode of life (as from walking to climbing) a race loses organs which were highly

useful to it in the former state, then, if it ever reverts to that former mode of (as from climbing to walking), those organs never return, but other organs are modified to take their place.

2. But (continues the Law), by virtue of the indestructibility of the past, the organism always preserves some trace of the intermediate stages. Thus, when a race reverts to its former state, there remain the traces of those modifications which its organs underwent while it was pursuing another mode of existence.

The first statement imposes a veto on any speculations as to descent that involve the reappearance of a vanished structure. It does not interfere with the cases in which old age seems to repeat the characters of youth, as in Ammonites, for here the old-age character may be similar, but obviously is not the same. The second statement furnishes a guide to the mode of life of the immediate ancestors, and is applicable to living as well as to fossil forms. It is from such persistent adaptive characters that some have inferred the arboreal nature of our own ancestors, or even of the ancestors of all mammals. To take but a single point, Dr. W. D. Matthew[1] finds traces of a former opposable thumb in several early Eocene mammals, and features dependent on this in the same digit of all mammals where it is now fixed.

THE STUDY OF HABITAT

The natural history of marine invertebrates is of particular interest to the geologist, but its study presents peculiar difficulties. The marine zoologist has long recognized that his early efforts with trawl and dredge threw little light on the depth in the sea frequented by his captures. The surface floaters, the swimmers of the middle and lower depths, and the crawlers on the bottom were confused in a single haul, and he has therefore devised means for exploring each region separately. The geologist, however, finds all these faunas mixed in a single deposit. He may even find with them the winged creatures of the air, as in the insect beds of Gurnet Bay, or the remains of estuarine and land animals.

Such mixtures are generally found in rocks that seem to have been deposited in quiet land-locked bays. Thus in a Silurian rock near Visby, Gotland, have been found creatures of such diverse habitat as a scorpion, a possibly estuarine *Pterygotus*, a large barnacle, and a crinoid of the delicate form usually associated with clear deep water. The lagoons of Solenhofen have preserved a strange mixture of land and sea life,

[1] 1904, *Amer. Natural.*, XXXVIII., 813.

without a trace of fresh or brackish water forms. *Archaeopteryx*, insects, flying reptiles, and creeping reptiles represent the air and land fauna; jelly-fish and the crinoids *Saccocoma* are true open-water wanderers; sponges and stalked crinoids were sessile on the bottom; starfish, sea-urchins, and worms crawled on the sea-floor; king-crabs, lobsters, and worms left their tracks on mud-flats; cephalopods swam at various depths; fishes ranged from the bottom mud to the surface waters. The Upper Ordovician Starfish bed of Girvan contains not only the crawling and wriggling creatures from which it takes its name, but stalked echinoderms adapted to most varied modes of life, swimming and creeping trilobites, and indeed representatives of almost all marine levels.

In the study of such assemblages we have to distinguish between the places of birth, of life, of death, and of burial, since, though these may all be the same, they may also be different. The echinoderms of the Starfish bed further suggest that closer discrimination is needed between the diverse habitats of bottom forms. Some of these were, I believe, attached to sea-weed; others grew up on stalks above the bottom; others clung to shells or stones; others lay on the top of the sea-floor; others were partly buried beneath its muddy sand; others may have groveled beneath it, connected with the overlying water by passages. Here we shall be greatly helped by the investigations of C. G. J. Petersen and his fellow-workers of the Danish Biological Station.[2] They have set an example of intensive study which needs to be followed elsewhere. By bringing up slabs of the actual bottom, they have shown that, even in a small area, many diverse habitats, each with its peculiar fauna, may be found, one superimposed on the other. Thanks to Petersen and similar investigators, exact comparison can now take the place of ingenious speculation. And that this research is not merely fascinating in itself, but illuminatory of wider questions, follows from the consideration that analysis of faunas and their modes of life must be a necessary preliminary to the study of migrations and geographical distribution.

THE TEMPO OF EVOLUTION

We have not yet done with the results that may flow from an analysis of adaptations. Among the many facts which, when considered from the side of animal structure alone, lead to transcendental theories with Greek names, there is the observa-

[2] See especially in his summary, "The Sea Bottom and its Production of Fish Food," Copenhagen, 1918.

tion that the relative rate of evolution is very different in races living at the same time. Since their remains are found often side by side, it is assumed that they were subject to the same conditions, and that the differences of speed must be due to a difference of internal motive force. After what has just been said you will at once detect the fallacy in this assumption. Professor Abel has recently maintained that the varying tempo of evolution depends on the changes in outer conditions. He compares the evolution of whales, sirenians, and horses during the Tertiary Epoch, and correlates it with the nature of the food. Roughly to summarize, he points out that from the Eocene onwards the sirenians underwent a steady, slow change, because, though they migrated from land to sea, they retained their habit of feeding on the soft water-plants. The horses, though they remained on land, display an evolution at first rather quick, then slower, but down to Pliocene times always quicker than that of the sirenians; and this is correlated with their change into eaters of grain, and their adaptation to the plains which furnish such food. The whales, like the sirenians, migrated at the beginning of the Tertiary from land to sea; but how different is their rate of evolution, and into what diverse forms have they diverged! At first they remained near the coasts, keeping to the ancestral diet, and, like the sirenians, changing but slowly. But the whales were flesh-eaters, and soon they took to hunting fish, and then to eating large and small cephalopods; hence from the Oligocene onwards the change was very quick, and in Miocene times the evolution was almost tempestuous. Finally, many whales turned to the swallowing of minute floating organisms, and from Lower Pliocene times, having apparently exhausted the possibilities of ocean provender, they changed with remarkable slowness.

Whether such changes of food or of other habits of life are, in a sense, spontaneous, or whether they are forced on the creatures by changes of climate and other conditions, makes no difference to the facts that the changes of form are a reaction to the stimuli of the outer world and that the rate of evolution depends on those outer changes.

Whether we have to deal with similar changes of form taking place at different times or in different places, or with diverse changes affecting the same or similar stocks at the same time and place, we can see the possibility that all are adaptations to a changing environment. There is then reason for thinking that ignorance alone leads us to assume some inexplicable force urging the races this way or that, to so-called advance or to apparent degeneration, to life or to death.

THE RHYTHM OF LIFE

The comparison of the life of a lineage to that of an individual is, up to a point, true and illuminating; but when a lineage first starts on its independent course (which really means that some individuals of a pre-existing stock enter a new field), then I see no reason to predict that it will necessarily pass through periods of youth, maturity, and old age, that it will increase to an acme of numbers, of variety, or of specialization, and then decline through a second childhood to ultimate extinction. Still less can we say that, as the individuals of a species have their allotted span of time, long or short, so the species or the lineage has its predestined term. The exceptions to those assertions are indeed recognized by the supporters of such views, and they are explained in terms of rejuvenescence, rhythmic cycles, or a grand despairing outburst before death. This phraseology is delightful as metaphor, and the conceptions have had their value in promoting search for confirmatory or contradictory evidence. But do they lead to any broad and fructifying principle? When one analyses them one is perpetually brought up against some transcendental assumption, some unknown entelechy that starts and controls the machine, but must forever evade the methods of our science.

The facts of recurrence, of rhythm, of rise and fall, of marvelous efflorescences, of gradual decline, or of sudden disappearances, all are incontestable. But if we accept the intimate relation of organism and environment, we shall surmise that on a planet with such a geological history as ours, with its recurrence of similar physical changes, the phenomena of life must reflect the great rhythmic waves that have uplifted the mountains and lowered the deeps, no less than every smaller wave and ripple that has from age to age diversified and enlivened the face of our restless mother.

To correlate the succession of living forms with all these changes is the task of the paleontologist. To attempt it he will need the aid of every kind of biologist, every kind of geologist. But this attempt is not in its nature impossible, and each advance to the ultimate goal will, in the future as in the past, provide both geologist and biologist with new light on their particular problems. When the correlation shall have been completed, our geological systems and epochs will no longer be defined by gaps in our knowledge, but will be the true expression of the actual rhythm of evolution. Lyell's great postulate of the uniform action of nature is still our guide; but we have ceased to confound uniformity with monotony. We return,

though with a difference, to the conceptions of Cuvier, to those numerous and relatively sudden revolutions of the surface of the globe which have produced the corresponding dynasties in its succession of inhabitants.

The Future

The work of a systematic paleontologist, especially of one dealing with rare and obscure fossils, often seems remote from the thought and practice of modern science. I have tried to show that it is not really so. But still it may appear to some to have no contact with the urgent problems of the world outside. That also is an error. Whether the views I have criticized or those I have supported are the correct ones is a matter of practical importance. If we are to accept the principle of predetermination, or of blind growth-force, we must accept also a check on our efforts to improve breeds, including those of man, by any other means than crossing and elimination of unfit strains. In spite of all that we may do in this way, there remain those decadent races, whether of ostriches or human beings, which "await alike the inevitable hour." If, on the other hand, we adopt the view that the life-history of races is a response to their environment, then it follows, no doubt, that the past history of living creatures will have been determined by conditions outside their control, it follows that the idea of human progress as a biological law ceases to be tenable; but, since man has the power of altering his environment and of adapting racial characters through conscious selection, it also follows that progress will not of necessity be followed by decadence; rather that, by aiming at a high mark, by deepening our knowledge of ourselves and of our world, and by controlling our energy and guiding our efforts in the light of that knowledge, we may prolong and hasten our ascent to ages and to heights as yet beyond prophetic vision.

HEREDITY

By Miss E. R. SAUNDERS

PRESIDENT OF THE BOTANICAL SECTION

BY the term Inheritance we are accustomed to signify the obvious fact of the resemblance displayed by all living organisms between offspring and parents, as the direct outcome of the contributions received from the two sides of the pedigree at fertilization: to indicate, in fact, owing to lack of knowledge of the workings of the hereditary process, merely the *visible*

consequence—the final result of a chain of events. Now, however, that we have made a beginning in our analysis of the stages which culminate in the appearance of any character, a certain looseness becomes apparent in our ordinary use of the word Heredity, covering as it does the two concomitant essentials, genetic potentiality and somatic expression—a looseness which may lead us into the paradoxical statement that inheritance is wanting in a case in which, nevertheless, the evidence shows that the genetic constitution of the children is precisely like that of the parents. When we say that a character is inherited no ambiguity is involved, because the appearance of the character entails the inheritance of the genetic potentiality. But when a character is stated not to be inherited it is not thereby indicated whether this result is due to environmental conditions, to genetic constitution, or to both causes combined. That we are now able in some measure to analyze the genetic potentialities of the individual is due to one of those far-reaching discoveries which change our whole outlook and bring immediately in their train a rapidly increasing array of new facts, falling at once into line with our new conceptions, or by some orderly and constant discrepancy pointing a fresh direction for attack. A historical survey of the steps by which we have advanced to the present state of our knowledge of Heredity has so frequently been given during the last twenty years that the briefest reference to this part of my subject will suffice.

The earliest attempts to frame some general law which would coordinate and explain the observed facts of inheritance were those of Galton and Pearson. Galton's observations led him to formulate two principles which he believed to be capable of general application—the Law of Ancestral Heredity and the Law of Regression. The Law of Ancestral Heredity was intended to furnish a general expression for the sum of the heritage handed on in any generation to the succeeding offspring. Superposed upon the working of this law were the effects of the Law of Regression, in which the average deviation from the mean of a whole population of any fraternal group within that population was expressed in terms of the average deviation of the parents. These expressions represent statements of averages which, in so far as they apply, hold only when large numbers are totaled together. They afford no means of certain prediction in the individual case. These and all similar statistical statements of the effects of inheritance take no account of the essentially physiological nature of this as of all other processes in the living organism. They leave us unenlightened on the fundamental

question of the nature of the means by which the results we witness came to pass. We obtain from them, as from the melting-pot, various new products whose properties are of interest from other viewpoints, but, corresponding to no biological reality, they have failed to bring us nearer to our goal—a fuller comprehension of the workings of the hereditary mechanism. Progress in this direction has resulted from the opposite method of inquiry—the study of a single character in a single line of descent, the method which deals with the unit in place of the mass. The revelation came with the opening of the present coloring matter anthocyanin in the petals of plants such as the stock and sweet pea. Our proof that two factors (at least) are here involved is obtained when we find that two true breeding forms devoid of color yield colored offspring when mated together. In this case the two complementary factors are carried, one by each of the two crossed forms. When both factors meet in the one individual, color is developed. We have in such cases the solution of the familiar, but previously unexplained, phenomenon of Reversion. Confirmatory evidence is afforded when among the offspring of such cross-bred individuals we find the simple 3 to 1 ratio of the one-factor difference replaced by a ratio of 9 to 7. Similarly we deduce from a ratio of 27 to 37 that three factors are concerned, from a ratio of 81 to 175 four factors, and so on. The occurrence of these higher ratios proves that the hereditary process follows the same course whatever the number of factors controlling the character in question.

And here I may pause to dwell for a moment upon a point of which it is well that we should remind ourselves from time to time, since, though tacitly recognized, it finds no explicit expression in our ordinary representation of genetic relations. The method of factorial analysis based on the results of interbreeding enables us to ascertain the least possible number of genetic factors concerned in controlling a particular somatic character, but what the total of such factors actually is we can not tell, since our only criterion is the number by which the forms we employ are found to differ. How many may be common to these forms remains unknown. In illustration I may take the case of surface character in the genera *Lychnis* and *Matthiola*. In *L. vespertina* the type form is hairy; in the variety *glabra*, recessive to the type, hairs are entirely lacking. Here all glabrous individuals have so far proved to be similar in constitution, and when bred with the type give a 3 to 1 ratio in F_2.[1] We speak of hairiness in this case, therefore, as being a

[1] Report to the Evolution Committee, Royal Society, I., 1902.

one-factor character. In the case of *Matthiola incana v. glabra*, of which many strains are in cultivation, it so happened that the commercial material originally employed in these investigations contained all the factors since identified as present in the type and essential to the manifestation of hairiness except one. Hence it appeared at first that here also hairiness must be controlled, as in *Lychnis*, by a single factor. But further experiment revealed the fact that though the total number of factors contained in these glabrous forms was the same, the respective factorial combinations were not identical. By interbreeding these and other strains obtained later, hairy F_1 cross-breds were produced giving ratios in F_2 which proved that at least four distinct factors are concerned.[2] Whereas, then, the glabrous appearance in *Lychnis* always indicates the loss (if for convenience we may so represent the nature of the recessive condition) *of one and the same factor*, analysis in the Stock shows that the glabrous condition results if *any factor out of a group of four* is represented by its recessive allelomorph. Hence we describe hairiness in the latter case as a four-factor character.

It will be apparent from the cases cited that we can not infer from the genetic analysis of one type that the factorial relations involved are the same for the corresponding character in another. That this should be so in wholly unrelated plants is not, perhaps, surprising, but we find it to be true also where the nature of the characteristic and the relationship of the types might have led us to expect uniformity. This is well seen in the case of a morphological feature distinctive of the N. O. Gramineæ. The leaf is normally ligulate, but individuals are occasionally met with in which the ligule is wanting. In these plants, as a consequence, the leaf blade stands nearly erect instead of spreading out horizontally. Nilsson-Ehle[3] discovered that in oats there are at least four and possibly five distinct factors determining ligule formation, all with equal potentialities in this direction. Hence, only when the complete series is lacking is the ligule wanting. In mixed families the proportion of ligulate to non-ligulate individuals depends upon the number of these ligule-producing factors contained in the dominant parent. Emerson[4] found, on the other hand, that in maize mixed families showed constantly a 3 to 1 ratio, indicating the existence of only one controlling factor.

[2] *Proc. Roy. Soc.*, B, Vol. 85, 1912.

[3] "Kreuzungsuntersuchungen an Hafer und Weizen," Lund, 1909.

[4] Annual Report of the Agricultural Experiment Station of the University of Nebraska, 1912.

From time to time the objection has been raised that the Mendelian type of inheritance is not exhibited in the case of specific characters. That no such sharp line of distinction can be drawn between the behavior of varietal and specific features has been repeatedly demonstrated. As a case in point and one of the earliest in which clear proof of Mendelian segregation was obtained, we may instance *Datura*. The two forms, *D. Stramonium* and *D. Tatula*, are ranked by all systematists as distinct species. Among other specific differences is the flower color. The one form has purple flowers, the other pure white. In the case of both species a variety *inermis* is known in which the prickles characteristic of the fruit in the type are wanting. It has been found that in whatever way the two pairs of opposite characters are combined in a cross between the species, the F_2 generation is mixed, comprising the four possible combinations in the proportions which we should expect in the case of two independently inherited pairs of characters, when each pair of opposites shows the dominant-recessive relation. Segregation is as sharp and clean in the specific character flower color as in the varietal character of the fruit. Among the latest additions to the list of specific hybrids showing Mendelian inheritance, those occurring in the genus *Salix* are of special interest, since heretofore the data available had been interpreted as conflicting with the Mendelian conception. The recent observations of Heribert-Nilson[5] show that those characters which are regarded by systematists as constituting the most distinctive marks of the species are referable to an extremely simple factorial system, and that the factors mendelize in the ordinary way. Furthermore, these specific-character factors control not only the large constant *morphological features*, but *fundamental reactions* such as those determining the condition of physiological equilibrium and vitality in general. In so far as any distinction can be drawn between the behavior of factors determining the varietal as opposed to the specific characters of the systematist, Heribert-Nilsson concludes that the former are more localized in their action, while the latter produce more diffuse results, which may affect almost all the organs and functions of the individual, and thus bring about striking alterations in the general appearance. *S. caprea*, for example, is regarded as the reaction product of two distinct factors which together control the leaf-breadth character, but which also affect, each separately and in a different way, leaf form, leaf color, height,

[5] "Experimentelle Studien über Variabilität, Spaltung, Artbildung und Evolution in der Gattung Salix," 1918.

and the periodicity of certain phases. We can not, however, draw a hard-and-fast line between the two categories. The factor controlling a varietal characteristic often produces effects in different parts of the plant. For example, the factors which lead to the production of a colored flower no doubt also in certain cases cause the tinging seen in the vegetative organs, and affect the color of the seed. Heribert-Nilsson suggests that fertility between species is a matter of close similarity in genotypic (factorial) constitution rather than of outward morphological resemblance. Forms sundered by the systematist on the ground of gross differences in certain anatomical features may prove to be more nearly related because the differentiating factors happen to control less conspicuous features.

THE SUPPLY OF OXYGEN TO THE TISSUES

By J. R. BARCROFT

PRESIDENT OF THE PHYSIOLOGICAL SECTION

PROMINENT among the pathological conditions which claimed attention during the war was that of insufficient oxygen supply to the tissues, or anoxæmia. For this there were several reasons; on the one hand, anoxæmia clearly was a factor to be considered in the elucidation of such conditions as are induced by gas poisoning, shock, etc. On the other hand, knowledge had just reached the point at which it was possible to discuss anoxæmia on a new level. It is not my object in the present address to give any account of war-physiology—the war has passed, and I, for one, have no wish to revive its memories, but anoxæmia remains, and, as it is a factor scarcely less important in peace than in war pathology, I think I shall not do wrong in devoting an hour to its consideration.

The object of my address, therefore, will be to inquire, and, if possible, to state, where we stand; to sift, if I can, the knowledge from the half-knowledge; to separate what is ascertained as the result of unimpeachable experiment from what is but guessed on the most likely hypothesis. In war it was often necessary to act on defective information, because action was necessary and defective information was the best that was to be had. In this, as in many other fields of knowledge, the whole subject should be reviewed, the hypotheses tested experimentally, and the gaps filled in. The sentence which lives in my mind as embodying the problem of anoxæmia comes from the

pen of one who has given more concentrated thought to the subject than perhaps any other worker—Dr. J. S. Haldane. It runs, "Anoxæmia not only stops the machine, but wrecks the machinery." This phrase puts the matter so clearly that I shall commence by an inquiry as to the limits within which it is true.

Anything like complete anoxæmia stops the machine with almost incredible rapidity. It is true that the breath can be held for a considerable time, but it must be borne in mind that the lungs have a volume of about three liters at any moment, that they normally contain about half a liter of oxygen, and that this will suffice for the body at rest for upwards of two minutes. But get rid of the residual oxygen from the lungs only to the very imperfect extent which is possible by the breathing of some neutral gas, such as nitrogen, and you will find that only with difficulty will you endure half a minute. Yet even such a test gives no real picture of the impotence of the machine—which is the brain—to "carry on" in the absence of oxygen. For, on the one hand, nearly a quarter of a minute elapses before the reduced blood gets to the capillary in the brain, so that the machine has only carried on for the remaining quarter of a minute; on the other hand, the arterial blood under such circumstances is far from being completely reduced—in fact, it has very much the composition of ordinary venous blood, which means that it contains about half its usual quotum of oxygen. It seems doubtful whether complete absence of oxygen would not bring the brain to an instantaneous standstill. So convincing are the experimental facts to any one who has tested them for himself, that I will not further labor the power of anoxæmia to stop the machine. I will, however, say a word about the assumption which I have made that the machine in this connection is the brain.

It can not be stated too clearly that anoxæmia in the last resort must affect every organ of the body directly. Stoppage of the oxygen supply is known, for instance, to bring the perfused heart to a standstill, to cause a cessation of the flow of urine, to produce muscular fatigue, and at last immobility, but from our present standpoint these effects of anoxæmia seem to me to be out of the picture, because the brain is so much the most sensitive to oxygen want. Therefore, if the problem is the stoppage of the machine due to an insufficient general supply of oxygen, I have little doubt that the machine stops because the brain stops, and here at once I am faced with the question how far is this assumption and how far is it proven fact? I freely answer that research in this field is urgent; at present there is

too great an element of assumption, but there is also a certain amount of fact.

To what extent does acute anoxæmia in a healthy subject wreck the machinery as well as stop the machine? By acute anoxæmia I mean complete or almost complete deprivation of oxygen which, in the matter of time, is too short to prove fatal. It is not easy to obtain quite clear-cut experiments in answer to the above question. No doubt many data might be quoted of men who have recovered from drowning, etc. Such data are complicated by the fact that anoxæmia has only been a factor in their condition; other factors, such as accumulation of carbonic acid, may also have contributed to it. The remarkable fact about most of them, however, is the slightness of the injury which the machine has suffered. These data, therefore, have a value in so far as they show that a very great degree of anoxæmia, if acute and of short duration, may be experienced with but little wreckage to the machine. They have but little value in showing that such wreckage is due to the anoxæmia, because the anoxæmia has not been the sole disturbance.

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It is rather fashionable at present to say that "the whole question of acidosis and anoxæmia is in a hopeless muddle." To this I answer that, if it is in a muddle, I believe the reason to be largely because schools of thought have rallied round words and have taken sides under the impression that they have no common ground. The "muddle," in so far as it exists, is not, I think, by any means hopeless; but I grant freely enough that we are rather at the commencement than at the end of the subject, and that much thought and much research must be given, firstly, in getting accurate data, and, secondly, on relating cause and effect, before the whole subject will seem simple. No effort should be spared to replace indirect by direct measurements. My own inference with regard to changes of the reaction of the blood, based on interpretations of the dissociation curve, should be checked by actual hydrogen ion measurements, as has been done by Hasselbach and is being done by Donegan and Parsons. Meakins also is, I think, doing great work by actually testing the assumptions made by Haldane and himself as regards the oxygen in arterial blood.

For the anoxic type of anoxæmia two forms of compensation at once suggest themselves. The one is increased hemoglobin in the blood; the other is increased blood-flow through the tissues. Let us, along the lines of the calculations already made, endeavor to ascertain how far these two types of compensation

will really help. To go back to the extreme anoxic case already cited, in which the hemoglobin was 66 per cent. saturated, let us, firstly, see what can be accomplished by an increase of the hemoglobin value of the blood. Such an increase takes place, of course, at high altitudes. Let us suppose that the increase is on the same grand scale as the anoxæmia, and that it is sufficient to restore the actual quantity of oxygen in one c.c. of blood to the normal. This, of course, means a rise in the hemoglobin value of the blood from 100 to 150 on the Gowers' scale. Yet even so great an increase in the hemoglobin will only increase the oxygen taken up in the capillary from each c.c. of blood from .031 to .036 c.c., and will therefore leave it far short of the .06 c.c. which every cubic centimeter of normal blood was giving to the tissue. So much, then, for increased hemoglobin. It gives a little, but only a little, respite. Let us turn, therefore, to increased blood-flow.

In the stagnant type of anoxæmia the principal change which is seen to take place is an increase in the quantity of hemoglobin per cubic millimeter of blood.

This increase is secondary to a loss of water in the tissues, the result in some cases, as appears from the work of Dale, Richards, and Laidlaw, of a formation of histamine in the tissues. Whether this increase of hemoglobin is to be regarded as merely an accidental occurrence or as a compensation is difficult to decide at present. Roughton's calculations rather surprised us by indicating that increased hemoglobin acted less efficiently as a compensatory mechanism than we had expected. This conclusion may have been due to the inaccuracy of our assumptions. I must therefore remind you that much experimental evidence is required before the assumptions which are made above are anything but assumptions. But, so far as the evidence available at the present time can teach any lesson, that lesson is this: The only way of dealing satisfactorily with the anoxic type of anoxæmia is to abolish it by in some way supplying the blood with oxygen at a pressure sufficient to saturate it to the normal level.

It has been maintained strenuously by the Oxford school of physiologists that Nature actually did this; that when the partial pressure in the air-cells of the lung was low the cellular covering of that organ could clutch at the oxygen and force it into the blood at an unnatural pressure, creating a sort of forced draught. This theory, as a theory, has much to recommend it. I am sorry to say, however, that I can not agree with it on the present evidence. I will only make a passing allusion to the

experiment which I performed in order to test the theory, living for six days in a glass respiration-chamber in which the partial pressure of oxygen was gradually reduced until it was at its lowest—about 45 mm. Such a pressure, if the lung was incapable of creating what I have termed a forced draught, would mean an oxygen pressure of 38.40 mm. of mercury in the blood, a change sufficient to make the arterial blood quite dark in color, whereas did any considerable forced draught exist, the blood in the arteries would be quite bright in color. Could we but see the blood in the arteries, its appearance alone would almost give the answer as to whether or no oxygen was forced, or, in technical language, secreted, through the lung wall. And, of course, we could see the blood in the arteries by the simple process of cutting one of them open and shedding a little into a closed glass tube. To the surgeon this is not a difficult matter, and it was, of course, done. The event showed that the blood was dark, and the most careful analyses failed to discover any evidence that the body can force oxygen into the blood in order to compensate for a deficiency of that gas in the air.

Yet the body is not quite powerless. It can, by breathing more deeply, by increasing the ventilation of the lungs, bring the pressure of oxygen in the air cells closer to that in the atmosphere breathed than would otherwise be the case. I said just now that the oxygen in my lungs dropped to a minimal pressure of 45 mm.; but it did not remain at that level. When I bestirred myself a little it rose, as the result of increased ventilation of the lung, to 56 mm., and at one time, when I was breathing through valves, it reached 68 mm. Nature will do something, but what Nature does not do should be done by artifice. Exploration of the condition of the arterial blood is only in its infancy, yet many cases have been recorded in which in illness the arterial blood has lacked oxygen as much as or more than my own did in the respiration chamber when I was lying on the last day, with occasional vomiting, racked with headache, and at times able to see clearly only as an effort of concentration. A sick man, if his blood is as anoxic as mine was, can not be expected to fare better as the result, and so he may be expected to have all my troubles in addition to the graver ones which are, perhaps, attributable to some toxic cause. Can he be spared the anoxæmia? The result of our calculations, so far, points to the fact that the efficient way of combating the anoxic condition is to give oxygen. During the war it was given with success in the field in cases of gas-poisoning, and also special wards were formed on a small scale in this country in which the level

of oxygen in the atmosphere was kept up to about 40 per cent., with great benefit to a large percentage of the cases. The practise then inaugurated is being tested at Guy's Hospital by Dr. Hunt, who administered the treatment during the war.

Nor are the advantages of oxygen respiration confined to pathological cases. One of the most direct victims of anoxic anoxæmia is the airman who flies at great heights. Everything in this paper tends to show that to counteract the loss of oxygen which he sustains at high altitudes there is but one policy, namely, to provide him with an oxygen equipment which is at once as light and as efficient as possible—a consummation for which Haldane has striven unremittingly. And here I come to the personal note on which I should like to conclude. In the pages which I have read views have been expressed which differ from those which he holds in matters of detail—perhaps in matters of important detail. But Haldane's teaching transcends mere detail. He has always taught that the physiology of to-day is the medicine of to-morrow. The more gladly, therefore, do I take this opportunity of saying how much I think medicine owes and will owe, to the inspiration of Haldane's teaching.

INTENSIVE CULTIVATION

By Professor FREDERICK KEEBLE

PRESIDENT OF THE AGRICULTURAL SECTION

THERE is, so far as I can discover, no reason—save one—why I should have been called upon to assume the presidency of the Agricultural Section of the British Association, or why I should have been temerarious enough to accept so high an honor and such a heavy load of responsibility. For upon the theme of Agriculture as commonly understood I could speak, were I to speak at all, but as a scribe and not as one in authority. The one reason, however, which must have directed the makers of presidents in their present choice is, I believe, so cogent that despite my otherwise unworthiness I dared not refuse the invitation. It is that, in appointing me, agriculturists desired to indicate the brotherhood which they feel with intensive cultivators. As properly proud sisters of an improved tale they have themselves issued an invitation to the Horticultural Cinderella to attend their party, and in conformity with present custom, which requires each lady to bring her partner, I am here as her friend.

Nor could any invitation give me greater pleasure: for my devotion to Horticulture is profound and my affection that of a lover. My only fear is lest I should weary my hosts with her praises, for in conformity with this interpretation I propose to devote my address entirely to Horticulture—to speak of its performance during the war and of its immediate prospects.

Although that which intensive cultivators accomplished during the war is small in comparison with the great work performed by British agriculturists, yet nevertheless it is in itself by no means inconsiderable, and is, moreover, significant and deserves a brief record. That work may have turned and probably did turn the scale between scarcity and sufficiency; for, as I am informed, a difference of 10 per cent. in food supplies is enough to convert plenty into dearth. Seen from this standpoint the war-work accomplished by the professional horticulturist—the nurseryman, the florist, the glass-house cultivator, the fruit-grower and market gardener, and by the professional and amateur gardener and allotment holder assumes a real importance, albeit that the sum total of the acres they cultivated is but a fraction of the land which agriculturists put under the plough.

As a set-off against the relative smallness of the acreage brought during the war under intensive cultivation for food purposes, it is to be remembered that the yields per acre obtained by intensive cultivators are remarkably high. For example, skilled onion-growers compute their average yield at something less than 5 tons to the acre. A chrysanthemum-grower who turned his resources from the production of those flowers to that of onion obtained over an area of several acres a yield of 17 tons per acre. The average yield of potatoes under farm conditions in England and Wales is a little over 6 tons to the acre, whereas the army gardeners in France produced, from Scotch seed of Arran Chief which was sent to them, crops of 14 tons to the acre. Needless to say, such a rate of yield as this is not remarkable when compared with that obtained by potato-growers in the Lothians or in Lincolnshire, but it is nevertheless noteworthy as an indication of what I think may be accepted as a fact, that the average yields from intensive cultivation are about double those achieved by extensive methods.

The reduction of the acreage under soft fruits—strawberries, raspberries, currants, and gooseberries—which took place during the war gives some measure of the sacrifices—partly voluntary, partly involuntary—made by fruit-growers to the cause of war-food production. The total area under soft fruits

was 55,560 acres in 1913, by 1918 it had become 42,415, a decrease of 13,145 acres, or about 24 per cent. As would be expected, the reduction was greatest in the case of strawberries, the acreage of which fell from 21,692 in 1913 to 13,143 in 1918, a decrease of 8,549 acres, or about 40 per cent. It is unfortunate that bad causes often have best propagandas, for were the public made aware of such facts as these they would realize that the present high prices of soft fruits are of the nature of deferred premiums on war-risk insurances with respect to which the public claims were paid in advance and in full.

I should add that the large reduction of the strawberry acreage is a measure no less of the shortsightedness of official than of the public spirit of fruit-growers; for in the earlier years of the war many counties issued compulsory orders requiring the grubbing up and restriction of planting of fruit, and I well remember that one of my first tasks as Controller of Horticulture was to intervene with the object of convincing the enthusiasts of corn production that, in war, some peace-time luxuries become necessaries and that, to a sea-girt island beset by submarines, home-grown fruit most certainly falls into this category.

Those who were in positions of responsibility at that time will not readily forget the shifts to which they were put to secure and preserve supplies of any sorts of fruit which could be turned into jam—the collection of blackberries, the installation of pulping factories which Mr. Martin and I initiated, and the rushing of supplies of scarcely set jam to great towns, the populace of which, full of a steadfast fortitude in the face of military misfortune, was ominously losing its sweetness of disposition owing to the absence of jam and the dubiousness of the supply and quality of margarine.

But though the public lost in one direction it gained in another, and the reduction of the soft-fruit acreage meant—reckoned in terms of potatoes—an augmentation of supplies to the extent of over 100,000 tons. Equally notable was the contribution to food production made by the florists and nurserymen in response to our appeals. An indication of their effort is supplied by figures which, as president of the British Florists' Federation, Mr. George Munro—whose invaluable work for food production deserves public recognition—caused to be collected. They relate to the amount of food production undertaken by 100 leading florists and nurserymen. These men put 1.075 acres, out of a total of 1,775 acres used previously for flower-growing, to the purpose of food production, and they put

142 acres of glass out of a total of 218 acres to like use. I compute that their contribution amounted to considerably more than 12,000 tons of potatoes and 5,000 tons of tomatoes.

The market growers of Evesham and other districts famous for intensive cultivation also did their share by substituting for luxury crops, such as celery, those of greater food value, and even responded to our appeals to increase the acreage under that most chancy of crops—the onion, by laying down an additional 4,000 acres and thereby doubling a crop which more than any others supplies accessory food substances to the generality of the people.

In this connection the yields of potatoes secured by Germany and this country during the war period are worthy of scrutiny.

The pre-war averages were: Germany 42,450,000 tons, United Kingdom 6,950,000 tons; and the figures for 1914 were: Germany 41,850,000 tons, United Kingdom 7,476,000 tons.

Germany's supreme effort was made in 1915 with a yield of 49,570,000 tons, or about 17 per cent. above average. In that year our improvement was only half as good as that of Germany: our crop of 7,540,000 tons bettering our average by only 8 per cent. In 1916 weather played havoc with the crops in both countries, but Germany suffered most. The yield fell to 20,550,000 tons, a decrease of more than 50 per cent., whilst our crop was down to 5,469,000 tons, a falling off of only 20 per cent. In the following year Germany could produce no more than 39,500,000 tons, or a 90 per cent. crop, whereas the United Kingdom raised 8,604,000 tons, or about 24 per cent. better than the average. Finally, whereas with respect to the 1918 crop in Germany no figures are available, those for the United Kingdom indicate that the 1917 crop actually exceeded that of 1918.

There is much food for thought in these figures, but my immediate purpose in citing them is to claim that of the million and three quarter tons increase in 1917 and 1918 a goodly proportion must be put to the credit of the intensive cultivator.

I regret that no statistics are available to illustrate the wartime food production by professional and amateur gardeners. That it was great I know, but how great I am unable to say. This however I can state, that from the day before the outbreak of hostilities, when, with the late Secretary of the Royal Horticultural Society, I started the intensive food-production campaign by urging publicly the autumn sowing of vegetables—a practice both then and now insufficiently followed—the amateur and professional gardeners addressed themselves to the work of producing food with remarkable energy and success. No less

remarkable and successful was the work of the old and new allotment holders, so much so indeed that at the time of the Armistice there were nearly a million and a half allotment holders cultivating upwards of 125,000 acres of land: an allotment for every five households in England and Wales. It is a pathetic commentary on the Peace that Vienna should find itself obliged to do now what was done here during the war—namely, convert its parks and open spaces into allotments in order to supplement a meager food supply.

This brief review of war-time intensive cultivation would be incomplete were it to contain no reference to intensive cultivation by the armies at home and abroad. From small beginnings, fostered by the distribution by the Royal Horticultural Society of supplies of vegetable seeds and plants to the troops in France, army cultivation assumed under the direction of Lord Harcourt's Army Agricultural Committee extraordinarily large dimensions: a bare summary must suffice here, but a full account may be found in the report presented by the Committee to the House of Parliament and published as a Parliamentary Paper.

In 1918 the armies at home cultivated 5,869 acres of vegetables. In the summer of that year the camp and other gardens of our armies in France were producing 100 tons of vegetables a day. These gardens yielded, in 1918, 14,000 tons of vegetables, worth, according to my estimate, a quarter of a million pounds sterling, but worth infinitely more if measured in terms of benefit to the health of the troops.

As the result of General Maude's initiative, the forces in Mesopotamia became great gardeners, and in 1918 produced 800 tons of vegetables, apart altogether from the large cultivations carried out by His Majesty's Forces in that wonderfully fertile land. In the same year the forces at Salonika had about 7,000 acres under agricultural and horticultural crops, and raised produce which effected a saving of over 50,000 shipping tons.

Even from this brief record it will, I believe, be conceded that intensive cultivation played a useful and significant part in the war: what, it may be asked, is the part which it is destined to play in the future? So far as I am able to learn, there exist in this country two schools of thought or opinion on the subject of the prospects of intensive cultivation, the optimistic and the pessimistic school. The former sees visions of large communities of small cultivators colonizing the countryside of England, increasing and multiplying both production and them-

selves, a numerous, prosperous and happy people and a sure shield in time of war against the menace of submarines and starvation. Those on the other hand who take the pessimistic view, point to the many examples of smallholders who "plough with pain their native lea and reap the labor of their hands" with remarkably small profit to themselves or to the community—smallholders like those in part of Warwickshire, who can just manage by extremely hard labor to maintain themselves, or, like those in certain districts of Norfolk, who have let their holdings tumble down into corn and who produce no more and indeed less to the acre than do the large farmers who are their neighbors.

Before making any attempt to estimate the worth of these rival opinions it may be observed that the war has brought a large reinforcement of strength to the rank of the optimists. A contrast of personal experiences illustrates this fact. When in the early days of the war I felt it my duty to consult certain important county officials with the object of securing their support for schemes of intensive food production, I carried away from the conference one conclusion only: that the counties of England were of two kinds, those which were already doing much and were unable therefore to do more, and those which were doing little because there was no more to be done. In spite of this close application of the doctrine of Candide—that all is for the best in the best of all possible worlds—I was able to set up some sort of county horticultural organization, scrappy, amateurish, but enthusiastic, and the work done by that organization was on the average good; so much so indeed that when after the Armistice I sought to build up a permanent county horticultural organization I was met by a changed temper. The schemes which the staff of the Horticultural Division had elaborated as the result of experience during the war were received and adopted with a cordiality which I like to think was evoked no less by the excellence of the schemes themselves than by the promise of liberal financial assistance in their execution. Thus it came about that when the time arrived for me to hand over the controllership of Horticulture to my successor, almost every county had established a strong County Horticultural Committee, and the chief counties from the point of view of intensive cultivation had provided themselves with a staff competent to demonstrate not only to cottagers and allotment holders, but also to smallholders and commercial growers, the best methods of intensive cultivation. In the most important counties horticultural superintendents with knowledge of commer-

cial fruit-growing were being appointed, and demonstration fruit and market-garden plots, designed on lines laid down by Captain Wellington and his expert assistants, were in course of establishment. The detailed plans for these links in a national chain of demonstration and trial plots have been published, and any one who will study them will, I believe, recognize that they point the way to the successful development of a national system of intensive cultivation.

By means of these county stations the local cultivator may learn how to plant and maintain his fruit plantation and how to crop his vegetable quarters, what stock to run and what varieties to grow.

Farm stations—with the Research stations established previously by the Ministry; Long Ashton and East Malling for fruit investigations; the Lea Valley Growers' Association and Rothamstead for investigation of soil problems and pathology; the Imperial College of Science for research in plant physiology, together with a couple of stations, contemplated before the war, for local investigation of vegetable cultivation; an alliance with the Royal Horticultural Society's Research Station at Wisley, and with the John Innes Horticultural Institute for research in genetics; the Ormskirk Potato Trial Station; a Poultry Institute; and, most important of all from the point of view of education, the establishment at Cambridge of a School of Horticulture—constitute a horticultural organization which, if properly coordinated and—dare I say it?—directed, should prove of supreme value to all classes of intensive cultivators. To achieve that result, however, something more than a permissive attitude on the part of the ministry is required, and in completing the design of it I had hoped also to remain a part of that organization long enough to assist in securing its functioning as a living, plastic, resourceful, directive force—a horticultural cerebrum. Thus developed, it is my conviction that this instrument is capable of bringing Horticulture to a pitch of perfection undreamed of at the present time either in this country or elsewhere.

THE PROBLEMS OF ANTHROPOLOGY

By Professor KARL PEARSON

PRESIDENT OF THE ANTHROPOLOGICAL SECTION

ANTHROPOLOGY—the Understanding of Man—should be, if Pierre Charron were correct, the true science and the

true study of mankind.[1] We might anticipate that in our days —in this era of science—anthropology in its broadest sense would occupy the same exalted position that theology occupied in the Middle Ages. We should hail it "Queen of the Sciences," the crowning study of the academic curriculum. Why is it that we are Section H and not Section A? If the answer be given that such is the result of historic evolution, can we still be satisfied with the position that anthropology at present takes up in our British universities and in our learned societies? Have our universities, one and all, anthropological institutes well filled wth enthusiastic students, and are there brilliant professors and lecturers teaching them not only to understand man's past, but to use that knowledge to forward his future? Have we men trained during a long life of study and research to represent our science in the arena, or do we largely trust to dilettanti—to retired civil servants, to untrained travellers or colonial medical men for our knowledge, and to the anatomist, the surgeon, or the archeologist for our teaching? Needless to say, that for the study of man we require the better part of many sciences, we must draw for contributions on medicine, on zoology, on anatomy, on archeology, on folk-lore and travel-lore, nay, on history, psychology, geology, and many other branches of knowledge. But a hotch-potch of the facts of these sciences does not create anthropology. The true anthropologist is not the man who has merely a wide knowledge of the conclusions of other sciences, he is the man who grasps their bearing on mankind and throws light on the past and present factors of human evolution from that knowledge.

I am afraid I am a scientific heretic—an outcast from the true orthodox faith—I do not believe in science for its own sake. I believe only in science for man's sake. You will hear on every side the argument that it is not the aim of science to be utile, that you must pursue scientific studies for their own sake and not for the utility of the resulting discoveries. I think that there is a great deal of obscurity about this attitude, I will not say nonsense. I find the strongest supporters of "science for its own sake" use as the main argument for the pursuit of not immediately utile researches that these researches will be useful some day, that we can never be certain when they will turn out to be of advantage to mankind. Or, again, they will appeal to non-utile branches of science as providing a splendid intellectual

[1] "La vraye science et le vray estude de l'homme c'est l'Homme." Pierre Charron, *De la Sagesse*, Préface du Premier Livre, 1601. Pope, with his "The proper study of mankind is Man," 1733, was, as we might anticipate, only a plagiarist.

training—as if the provision of highly trained minds was not itself a social function of the greatest utility! In other words, the argument from utility is in both cases indirectly applied to justify the study of science for its own sake. In the old days the study of hyperspace—space of higher dimensions than that of which we have physical cognizance—used to be cited as an example of a non-utile scientific research. In view of the facts: (i) that our whole physical outlook on the universe—and with it I will add our whole philosophical and theological outlook—are taking new aspects under the theory of Einstein; and (ii) that study of the relative influences of nature and nurture in man can be reduced to the trigonometry of polyhedra in hyper-space—we see how idle it is to fence off any field of scientific investigation as non-utile.

Yet are we to defend the past of anthropology—and, in particular, of anthropometry—as the devotion of our science to an immediate non-utile which one day is going to be utile in a glorious and epoch-making manner, like the Clifford-Einstein suggestion of the curvature of our space? I fear we can take no such flattering unction to our souls. I fear that "the best is yet to be" can not be said of our multitudinous observations on "height-sitting" or on the censuses of eye or hair colors of our population. These things are dead almost from the day of their record. It is not only because the bulk of their recorders were untrained to observe and measure with scientific accuracy, it is not only because the records in nine out of ten cases omit the associated factors without which the record is valueless. It is because the progress of mankind in its present stage depends on characters wholly different from those which have so largely occupied the anthropologist's attention. Seizing the superficial and easy to observe, he has let slip the more subtle and elusive qualities on which progress, on which national fitness for this or that task essentially depends. The pulse-tracing, the reaction-time, the mental age of the men under his control are far more important to the commanding officer—nay, I will add, to the employer of labor—than any record of span, of head-measurement, or pigmentation categories. The psycho-physical and psycho-physiological characters are of far greater weight in the struggle of nations to-day than the superficial measurement of man's body. Physique, in the fullest sense, counts something still, but it is physique as measured by health, not by stature or eye-color. But character, strength of will, mental quickness count more, and if anthropometry is to be useful to the state it must turn from these rusty old weapons, these measurements of

stature and records of eye-color to more certain appreciation of bodily health and mental aptitude—to what we may term "vigorimetry" and to psychometry.

Some of you may be inclined to ask: And how do you know that these superficial size-, shape-, and pigment-characters are not closely associated with measurements of soundness of body and soundness of mind? The answer to this question is twofold, and I must ask you to follow me for a moment into what appears a totally different subject. I refer to a "pure race." Some biologists apparently believe they can isolate a pure race, but in the case of man, I feel sure that purity of race is a merely relative term. For a given character one race is purer than a second, if the scientific measure of variation of that character is less than it is in the second. In loose wording, for we can not express ourselves accurately without mathematical symbols, that race is purer for which on the average the individuals are closer to type for the bulk of ascertainable characters than are the characters in a second race. But an absolutely pure race in man defies definition. The more isolated a group of men has remained, the longer it has lived under the same environment, and the more limited its habitat, the less variation from type it will exhibit, and we can legitimately speak of it as possessing greater purity. We, most of us, probably believe in a single origin of man. But as anthropologists we are inclined to speak as if at the dawn of history there were a number of pure races, each with definite physical and mental characteristics; if this were true, which I do not believe, it could only mean that up to that period there had been extreme isolation, extremely differentiated environment, and so marked differences in the direction and rate of mental and physical evolution. But what we know historically of folk-wanderings, folk-mixings, and folk-absorptions have undoubtedly been going on for hundreds of thousands of years, of which we know only a small historic fragment. Have we any real reason for supposing that "purity of race" existed up to the beginning of history, and that we have all got badly mixed up since?

Let us, however, grant that there were purer races at the beginning of history than we find to-day. Let us suppose a Nordic race with a certain stature, a given pigmentation, a given shape of head, and a given mentality. And again, we will suppose an Alpine race, differing markedly in type from the Nordic race. What happens if we cross members of the two races and proceed to a race of hybrids? A Mendelian would tell us that these characters are sorted out like cards from a pack in all sorts

of novel combinations. A Nordic mentality will be found with short stature and dark eyes. A tall but brachycephalic individual will combine Alpine mentality with blue eyes. Without accepting fully the Mendelian theory we can at least accept the result of mass observations, which show that the association between superficial physical measurements and mentality is of the slenderest kind. If you keep within one class, my own measurements show me that there is only the slightest relation between intelligence and the size and shape of the head. Pigmentation in this country seems to have little relation to the incidence of disease. Size and shape of head in man have been taken as a rough measure of size and shape of brain. They can not tell you more—perhaps not as much as brain-weight—and if brain-weight were closely associated with intelligence, then man should be at his intellectual prime in his teens.

Again, too often is this idea of close association of mentality and physique carried into the analysis of individuals within a human group, *i.e.*, of men belonging to one or another of the many races which have gone to build up our population. We talk as if it was our population which was mixed, and not our germplasm. We are accustomed to speak of a typical Englishman. For example, Charles Darwin; we think of his mind as a typical English mind, working in a typical English manner, yet when we come to study his pedigree we seek in vain for "purity of race." He is descended in four different lines from Irish kinglets; he is descended in as many lines from Scottish and Pictish kings. He has Manx blood. He claims descent in at least three lines from Alfred the Great, and so links up with Anglo-Saxon blood, but he links up also in several lines with Charlemagne and the Carlovingians. He sprang also from the Saxon Emperors of Germany, as well as from Barbarossa and the Hohenstaufens. He had Norwegian blood and much Norman blood. He had descent from the Duke of Bavaria, of Saxony, of Flanders, the Princes of Savoy, and the Kings of Italy. He had the blood in his veins of Franks, Alamans, Merovingians, Burgundians, and Longobards. He sprang in direct descent from the Hun rulers of Hungary and the Greek Emperors of Constantinople. If I recollect rightly, Ivan the Terrible provides a Russian link. There is probably not one of the races of Europe concerned in folk-wanderings which has not a share in the ancestry of Charles Darwin. If it has been possible in the case of one Englishman of this kind to show in a considerable number of lines how impure is his race, can we venture to assert that if the like knowledge were possible of attainment, we could

expect greater purity of blood in any of his countrymen? What we are able to show may occur by tracing an individual in historic times, wherever physical barriers did not isolate a limited section of mankind? If there ever was an association of definite mentality with physical characters, it would break down as soon as race mingled freely with race, as it has done in historic Europe. Isolation or a strong feeling against free inter-breeding—as in a color differentiation—could alone maintain a close association between physical and mental characters. Europe has never recovered from the general hybridization of the folk-wanderings, and it is only the cessation of wars of conquest and occupation, the spread of the conception of nationality and the reviving consciousness of race, which is providing the barriers which may eventually lead through isolation to a new linking-up of physical and mental characters.

In a population which consists of non-intermarrying castes, as in India, physique and external appearance may be a measure of the type of mentality. In the highly and recently hybridized nations of Europe there are really but few fragments of "pure races" left, and it is hopeless to believe that anthropometric measurements of the body or records of pigmentation are going to help us to a science of the psycho-physical characters of man which will be useful to the state. The modern state needs in its citizens vigor of mind and vigor of body, but these are not characters with which the anthropometry of the past has largely busied itself. In a certain sense the school medical officer and the medical officer of health are doing more state service of an anthropological character than the anthropologists themselves.

These doubts have come very forcibly to my notice during the last few years. What were the anthropologists as anthropologists doing during the war? Many of them were busy enough and doing valuable work because they were anatomists, or because they were surgeons, or perhaps even because they were mathematicians. But as anthropologists, what was their position? The whole period of the war produced the most difficult problems in folk-psychology. There were occasions innumerable where thousands of lives and most heavy expenditure of money might have been saved by a greater knowledge of what creates and what damps folk movements in the various races of the world. India, Egypt, Ireland, even our present relations with Italy and America, show only too painfully how difficult we find it to appreciate the psychology of other nations. We shall not surmount these difficulties until anthropologists take a wider view of the material they have to record and of the task

they have before them if they wish to be utile to the state. It is not the physical measurement of native races which is a fundamental feature of anthropometry to-day; it is the psychometry and what I have termed the vigorimetry of white- as well as of dark-skinned men that must become the main subjects of our study.

Some of you may consider that I am overlooking what has been contributed both in this country and elsewhere to the scienc of folk-psychology. I know at least that Wilhelm Wundt's[2] great work runs to ten volumes. But I also know that in its 5,452 pages there is not a single table of numerical measurements, not a single statement of the *quantitative* association between mental racial characters, nor, indeed, any attempt to show numerically the intensity of association between folk-mentality and folk customs and institutions. It is folk-psychology in the same stage of evolution as present-day sociology is in, or as individual psychology was in before the advent of experimental psychology and the correlational calculus. It is purely descriptive and verbal. I am not denying that many sciences must for a long period still remain in this condition, but at the same time I confess myself a firm disciple of Friar Roger Bacon[3] and of Leonardo da Vinci,[4] and believe that we can really know very little about a phenomenon until we can actually measure it and express its relations to other phenomena in quantitative form. Now you will doubtless suggest that sections of folk-psychology like Language, Religion, Law, Art—much that forms the substance of cultural anthropology—are incapable of quantitative treatment. I am not convinced that this standpoint is correct. Take only the first of these sections—*Language*. I am by no means certain that there is not a rich harvest to be reaped by the first man who can give unbroken time and study to the statistical analysis of language. Whether he start with roots or with words to investigate the degree of resemblance in languages of the same family, he is likely, before he has done, to learn a great deal about the relative closeness and order of evolution of cognate tongues, whether those tongues be Aryan or Sudanese. And the methods applicable in the case of language

[2] Its last volume also bears evidence of the non-judicial mind of the writer, who expresses strong opinions about recent events in the language of the party historian rather than the man of science.

[3] He who knows not Mathematics can not know any other science, and what is more can not discover his own ignorance or find its proper remedies.

[4] Nissuna humana investigatione si po dimandare vera scientia s'essa non passa per le matematiche dimonstratione.

will apply in the same manner to cultural habits and ideas. Strange as the notion may seem at first, there is a wide field in cultural anthropology for the use of those same methods which have revolutionized psychometric technique, to say nothing of their influence on osteometry.

The problems of cultural anthropology are subtle, but so indeed are the problems of anthropometry, and no instrument can be too fine if our analysis is to be final. The day is past when the arithmetic of the kindergarten sufficed for the physical anthropologist; the day is coming when mere verbal discussion will prove inadequate for the cultural anthropologist.

I do not say this merely in the controversial spirit. I say it because I want to find a remedy for the present state of affairs. I want to see the full recognition of anthropology as a leading science by the state. I want to see the recognition of anthropology by our manufacturers and commercial men, for it should be at least as important to them as chemistry or physics—the foundations of the anthropological institutes with their museums and professors in Hamburg and Frankfurt, have not yet found their parallels in commercial centers here. I want to see a fuller recognition of anthropology in our great scientific societies, both in their choice of members and in the memoirs published. If their doors are being opened to psychology under its new technique, may not anthropology also seek for fuller recognition?

It appears to me that if we are to place anthropology in its true position as the queen of the sciences, we must work shoulder to shoulder and work without intermittence in the following directions: anthropologists must not cease:

(i) To insist that our recorded material shall be such that it is at present or likely in the near future to be utile to the state, using the word "state" in its amplest sense.

(ii) To insist that there shall be institutes of anthropology, each with a full staff of qualified professors, whose whole energy and time shall be devoted to the teaching of and research in anthropology, ethnology and prehistory. At least three of our chief universities should be provided with such institutes.

(iii) To insist that our technique shall not consist in the mere statement of opinion on the facts observed, but shall follow, if possible with greater insight, the methods which are coming into use in epidemiology and psychology.

THE INDIVIDUAL CHILD AND METHODS OF TEACHING

By SIR ROBERT BLAIR

PRESIDENT OF THE EDUCATIONAL SECTION

IT is upon the latter problem, or group of problems, that experimental work has in the past been chiefly directed, and in the immediate future is likely to be concentrated with the most fruitful results. The recent advances in "individual psychology"—the youngest branch of that infant science—have greatly emphasized the need, and assisted the development, of individual teaching. The keynote of successful instruction is to adapt that instruction to the individual child. But before instruction can be so adapted, the needs and the capacities of the individual child must first be discovered.

Such discovery (as in all sciences) may proceed by two methods, by observation and by experiment.

1. The former method is in education the older. At one time, in the hands of Stanley Hall and his followers—the pioneers of the Child-Study movement—observation yielded fruitful results. And it is perhaps to be regretted that of late simple observation and description have been neglected for the more ambitious method of experimental tests. There is much that a vigilant teacher can do without using any special apparatus and without conducting any special experiment. Conscientious records of the behavior and responses of individual children, accurately described without any admixtures of inference or hypothesis, would lay broad foundations upon which subsequent investigators could build. The study of children's temperament and character, for example—factors which have not yet been accorded their due weight in education—must for the present proceed upon these simpler lines.

2. With experimental tests the progress made during the last decade has been enormous. The intelligence scale devised by Binet for the diagnosis of mental deficiency, the mental tests employed by the American army, the vocational tests now coming into use for the selection of employees—these have done much to familiarize, not school teachers and school doctors only, but also the general public, with the aims and possibilities of psychological measurement. More recently an endeavor has been made to assess directly the results of school instruction, and to record in quantitative terms the course of progress from year to year, by means of standardized tests for educational

attainments. In this country research committees of the British Association and of the Child-Study Society have already commenced the standardization of normal performances in such subjects as reading and arithmetic. In America attempts have been made to standardize even more elusive subjects, such as drawing, handwork, English composition, and the subjects of the curriculum of the secondary school.

This work of diagnosis has done much to foster individual and differential teaching—the adaptation of education to individual children, or at least to special groups and types. It has not only assisted the machinery of segregation—of selecting the mentally deficient child at one end of the scale and the scholarship child at the other end; but it has also provided a method for assessing the results of different teaching and methods as applied to these segregated groups. Progress has been most pronounced in the case of the sub-normal. The mentally defective are now taught in special schools, and receive an instruction of a specially adapted type. Some advance has more recently been made in differentiating the various grades and kinds of so-called deficiency; and in discriminating between the deficient and the merely backward and dull. With regard to the morally defective and delinquent little scientific work has been attempted in this country, with the sole exception of the new experiment initiated by the Birmingham justices. In the United States some twenty centers or clinics have been established for the psychological examination of exceptional children; and in England school medical officers and others have urged the need for "intermediate" classes or schools not only to accommodate backward and borderline cases and cases of limited or special defect (*e. g.*, "number-defect" and so-called "word-blindness") but also to act as clearing-houses.

In Germany and elsewhere special interest has been aroused in supernormal children. The few investigations already made show clearly that additional attention, expenditure, study, and provision will yield for the community a far richer return in the case of the super-normal than in the sub-normal.

At Harvard and elsewhere psychologists have for some time been elaborating psychological tests to select those who are best fitted for different types of vocation. The investigation is still only in its initial stages. But it is clear that if vocational guidance were based, in part at least, upon observations and records made at school, instead of being based upon the limited interests and knowledge of the child and his parents, then not only employers, but also employees, their work, and the community as

a whole, would profit. A large proportion of the vast wastage involved in the current system of indiscriminate engagement on probation would be saved.

The influence of sex, social status, and race upon individual differences in educational abilities has been studied upon a small scale. The differences are marked: and differences in sex and social status, when better understood, might well be taken into account both in diagnosing mental deficiency and in awarding scholarships. As a rule, however, those due to sex and race are smaller than is popularly supposed. How far these differences, and those associated with social status, are inborn and ineradicable, and how far they are due to differences in training and in tradition, can hardly be determined without a vast array of data.

The subjects taught and the methods of teaching have considerably changed during recent years. In the more progressive types of schools several broad tendencies may be discerned. All owe their acceptance in part to the results of scientific investigators.

1. Far less emphasis is now laid upon the *disciplinary value of subjects,* and upon subjects whose value is almost solely disciplinary. Following in the steps of a series of American investigators, Winch and Sleight in this country have shown very clearly that practise in one kind of activity produces improvements in other kinds of activities, only under very limited and special conditions. The whole conception of transfer of training is thus changed, or (some maintain) destroyed; and the earlier notion of education as the strengthening, through exercise, of certain general faculties has consequently been revolutionized. There is a tendency to select subjects and methods of teaching rather for their material than their general value.

2. Far less emphasis is now laid upon an advance according to strict *logical sequences* in teaching a given subject of the curriculum to children of successive ages. The steps and methods are being adapted rather to the natural capacities and interests of the child of each age. This genetic standpoint has received great help and encouragement from experimental psychology. Binet's own scale of intelligence was intended largely as a study in the mental development of the normal child. The developmental phases of particular characteristics (*e. g.,* children's ideals) and special characteristics of particular developmental phases (*e. g.,* adolescence) have been elaborately studied by Stanley Hall and his followers. Psychology, indeed, has done

much to emphasize the importance of the post-pubertal period—the school-leaving age, and the years that follow. Such studies have an obvious bearing upon the curriculum and methods for our new continuation schools. But it is, perhaps, in the revolutionary changes in the teaching methods of the infants' schools, changes that are already profoundly influencing the methods of the senior department, that the influence of scientific study has been most strongly at work.

3. Increasing emphasis is now being laid upon *mental and motor activities.* Early educational practise, like early psychology, was excessively intellectualistic. Recent child-study, however, has emphasized the importance on the motor and of the emotional aspects of the child's mental life. As a consequence, the theory and practise of education have assumed more of the pragmatic character which has characterized contemporary philosophy.

The progressive introduction of manual and practical subjects, both in and for themselves, and as aspects of other subjects, forms the most notable instance of this tendency. The educational process is assumed to start, not from the child's sensations (as nineteenth-century theory was so apt to maintain), but rather from his motor reactions to certain perceptual objects—objects of vital importance to him and to his species under primitive conditions, and therefore appealing to certain instinctive impulses. Further, the child's activities in the school should be, not indeed identical with, but continuous with, the activities of his subsequent profession or trade. Upon these grounds handicraft should now find a place in every school curriculum. It will be inserted both for its own sake, and for the sake of its connections with other subjects, whether they be subjects of school life, of after life, or of human life generally.

4. As a result of recent psychological work, more attention is now being paid to the *emotional, moral, and esthetic* activities. This is a second instance of the same reaction from excessive intellectualism. Education in this country has ever claimed to form character as well as to impart knowledge. Formerly, this aim characterized the public schools rather than the public elementary schools. Recently, however, much has been done to infuse into the latter something of the spirit of the public schools. The principle of self-government, for example, has been applied with success not only in certain elementary schools, but also in several colonies for juvenile delinquents. And, in the latter case, its success has been attributed by the initiators directly to the fact that it is a corollary of sound child-psychology.

Bearing closely upon the subject of moral and emotional training is the work of the psycho-analysts. Freud has shown that many forms of mental inefficiency in later life—both major (such as hysteria, neurosis, certain kinds of "shell-shock," etc.) and minor (such as lapses of memory, of action, slips of tongue and pen)—are traceable to the repression of emotional experiences in earlier life. The principles themselves may, perhaps, still be regarded as, in part, a matter of controversy. But the discoveries upon which they are based vividly illustrate the enormous importance of the natural instincts, interests, and activities, inherited by the child as part of his biological equipment; and, together with the work done by English psychologists such as Shand and McDougall upon the emotional basis of character, have already had a considerable influence upon educational theory in this country.

5. Increasing emphasis is now being laid upon *freedom* for individual effort and initiative. Here, again, the corollaries drawn from the psycho-analytic doctrines as to the dangers of repression are most suggestive. Already a better understanding of child-nature has led to the substitution of "internal" for "external" discipline; and the pre-determined routine demanded of entire classes is giving way to the growing recognition of the educational value of spontaneous efforts initiated by the individual, alone or in social cooperation with his fellows. In appealing for greater freedom still, the new psychology is in line with the more advanced educational experiments, such as the work done by Madame Montessori and the founders of the Little Commonwealth.

6. The *hygiene and technique of mental work* is itself being based upon scientific investigation. Of the numerous problems in the conditions and character of mental work generally, two deserve especial mention—fatigue, and the economy and technique of learning.

But of all the results of educational psychology, perhaps the most valuable is the slow but progressive inculcation of the whole teaching profession with a scientific spirit in their work, and a scientific attitude towards their pupils and their problems. Matter taught and teaching methods are no longer exclusively determined by mere tradition or mere opinion. They are being based more and more upon impartial observation, careful records, and statistical analysis—often assisted by laboratory technique—of the actual behavior of individual children.

EVOLUTION'S MOST ROMANTIC MOMENT

By Professor ROY L. MOODIE
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THERE is a small stream in northern Illinois which, since the last great ice sheet retreated, has cut its unhurried way through some forty feet of glacial alluvium and has thus exposed in its present bed the shales and rocks of the old Coal Period which was the witness of Nature's most important moment. The old Indian name "Mazon" still clings to the stream and it has become famous the world over for the wonder and importance of the relics of ancient animal and plant life found along its banks. Locally the creek is held in contempt, by the grown-ups as a breeding place for mosquitoes, and by the small boys because it is nowhere deep enough for a good

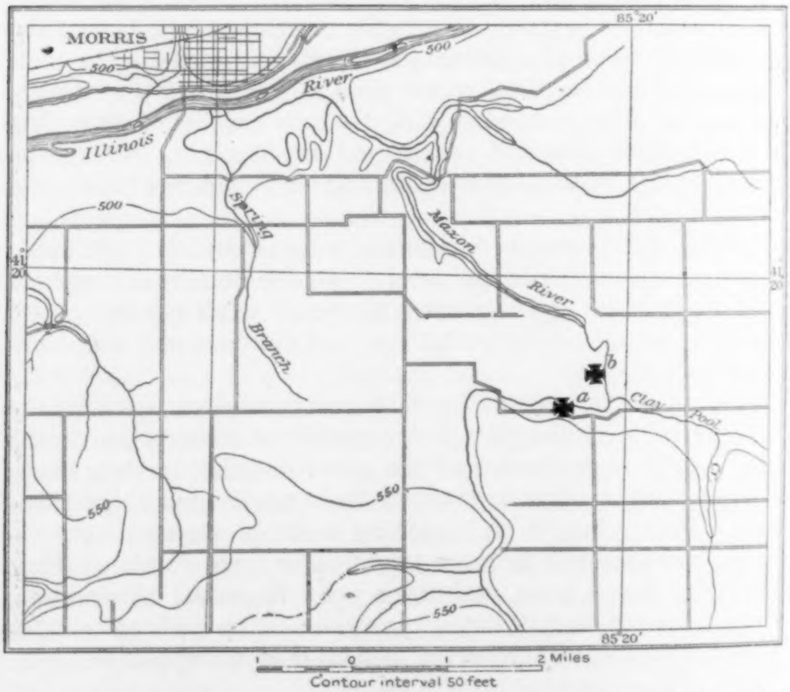


FIG. 1. TOPOGRAPHIC MAP OF THE MAZON CREEK, ILLINOIS, REGION, showing location of Fossil Beds.

FIG. 2. A shale bed in the banks of Mazon Creek, from which the fossil-bearing nodules were washed out. One is just sliding down the bank at the head of the hammer. Nodules thus exposed are split by the action of the frost, or by a blow of the collector's hammer, thus revealing the enclosed fossil. Only twelve of these nodules have contained four-footed animals, in seventy-five years collecting at this place.

swimming hole; fishing is almost unknown. The winding ripples, however, offer pleasant prospects to the casual visitor and its banks hold untold treasures for the student of ancient life.

The water has worn its placid way for centuries through several feet of grayish red shales, washing out an occasional rounded nodule, which, becoming exposed to the action of the frost, cracks and thus discloses its buried treasure of Paleozoic insect, centipede, spider, fish, leaf or, very, very rarely, *the remains of the first animal with legs,* which resembles so very closely our present mud-puppies. These small creatures are the oldest known land vertebrates and represent that most interesting and romantic phase when the animals which later resulted in the evolution of man were beginning to come out of the water and live a portion of their existence on land.

It is difficult for us, in these noisy times, to realize the stillness which pervaded all nature in this period when the animals were first considering an existence away from the water. It took eons of time for them to develop sufficient courage for a complete separation from their ancestral home. There were no voices of insect or bird in these later Paleozoic days, and the stillness was complete save for the wind, the rain and the thunder. The clouds doubtless sailed as quietly and as beauti-

FIG. 3. Nature tried the experiment of evolving four-footed animals in several places at about the same time. Some of her experiments are preserved for us in the shape of fossils. The one here shown was found by Sir William Dawson in a petrified tree trunk, on the coast of Nova Scotia. This animal had lost the ability to swim and is thus a more highly developed stage of animal life than the ones found at Mazon Creek.

fully through the sky then as now. The sun shone as brightly, and the rain was as pure and refreshing. There were no grasses for the raindrops to glisten on and no trees, save only those of the fern type, where the wind might moan an unheard complaint. The little creatures of the shore, the highest type of animal of their day, neither heard nor spoke. They were made aware of the approach of danger in the water by the sense

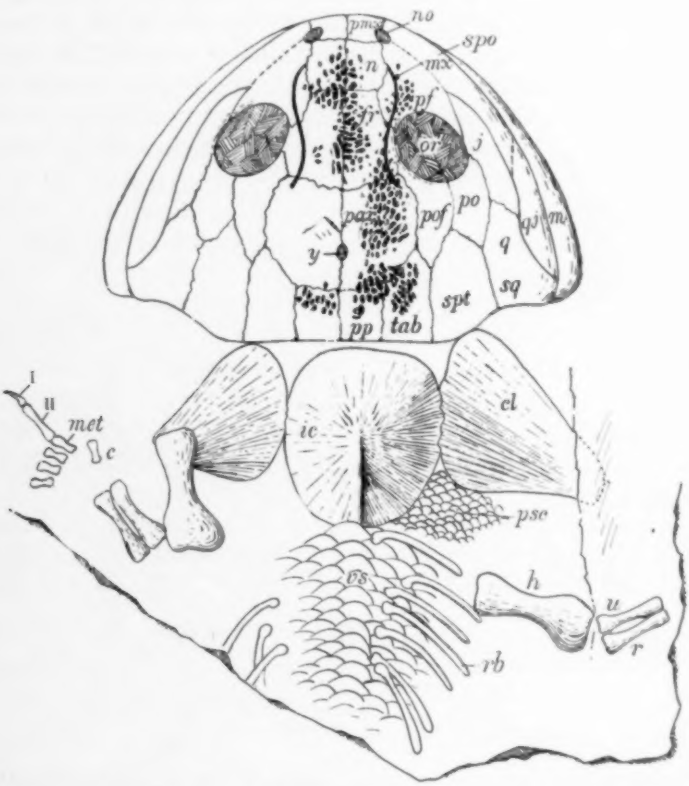


FIG. 4. At Linton, Ohio, in the Old Diamond mine, now long since abandoned, were discovered great numbers of the first animals with legs, though at a higher stage of development than those from Mazon Creek. The presence of scales on this fellow, who had a length of some 10 inches, do not indicate a fish ancestry, as might be supposed, but is rather an adaptation to aquatic life and similar structures are found even among many of the large reptiles of later times. The fossils of the coal are thus of the greatest importance in helping us to understand Evolution's most romantic moment.

organs in their skin, and on land they trusted to their large black eyes which set well exposed on top of their flat heads.

These little fellows, whose fossils we find on the banks of Mazon Creek, were timid adventurers and stayed close to the

shore of the old brackish bayou, the relics of which have come down to delight modern students in their attempt to unravel the story of the old world. None of them exceeded eight or at most ten inches in length, and they were often surpassed in size by even the centipedes which crawled through the swamps with them. But in potentialities of development these small knights of the Paleozoic surpassed anything the world had ever seen or will ever see again. They marked an important stage in this great progression of vertebrate life which has resulted in the development of the animate world as it is to-day. Had they not ventured on to the land, what to-day would have been the result? Would the world still be peopled only by denizens of the sea, or would the impulse for a higher life have come

FIG. 5. At the same time, and in the same lake perhaps, with the development of four-legged animals which were found at Linton, Ohio, lived creatures which had either very weak legs, as shown in the upper figure, or none at all, as shown below. The latter form had lost all vestiges of both limbs and limb girdles.

at some later time? This impulse for a higher existence than one in the water, the desire to more freely, enjoy the sun and the earth, must have been very strongly implanted in the Paleozoic creatures, for shortly after, some 10,000,000 years later, the same experiment was tried in far remote places. Illinois, however, may claim the credit of being the present spot where millions of years ago the vertebrate animals, in their desire to develop into higher beings, first began that most romantic

movement in all evolution. Rather we should say that we see here, doubtless, the result of millions of years of preparation for, and a tendency toward, a stage which was in progress when the world was still quite young.

Evidently this experiment was a success, for we find the fossils of kindred forms in old tree stumps which have been washed out of the sea-cliffs of Nova Scotia. These animals, though still small, were extremely active. Their bodies were covered with hard scales. They had sharp claws on their feet, and could not swim, for they had progressed so far in the passage from water to land that they had all but forgotten the water, and when they fell into the rain water within an old hollow sigillarian stump, they drowned and were thus fossilized to tell the tale to-day. An intermediate stage is found in Ohio, where they were inhabitants of an old swampy lake in which they lived by thousands in various stages of development. Discoveries in other parts of the world add but little to our general conception of this parting point in evolution. While fossils from Africa, Europe, Australia and India delight our eye and stir our interest in their diversity of structure, none approaches so closely to that parting of the ways as the tiny creatures found on the banks of Mazon Creek, in Illinois. We, as human beings, are interested in their aspirations, for, had they not aspired to a life on land, many, many millions of years ago, evolution would have missed its most romantic moment and the world to-day would not be what it is. The development of our race might have been deferred many millenniums.

AN ANCIENT MOONFISH

By Dr. DAVID STARR JORDAN
STANFORD UNIVERSITY

ONE of the strangest of all fishes that swim the seas is the great moonfish or Opah, called in California "*Mariposa*" (*Lampris luna* Gmelin). It is a broad flat fish almost as deep as long, with flattened sides, small toothless mouth, and short tail with strong muscles at its base. It lives in the open seas, reaching a weight of four hundred pounds, and is likely to appear on any coast, though always very rarely. It has low fins, no scales and its body colors are a rich brocade of maroon and red with white spots of varying sizes and over all a bright sheen of silver. Its flesh is rich, tender and toothsome, but no person is likely to taste it more than once, as the fish seldom appears twice in the same place. Young specimens I have never seen and I would not know where to look for them, for the fish probably casts its spawn in the open sea.

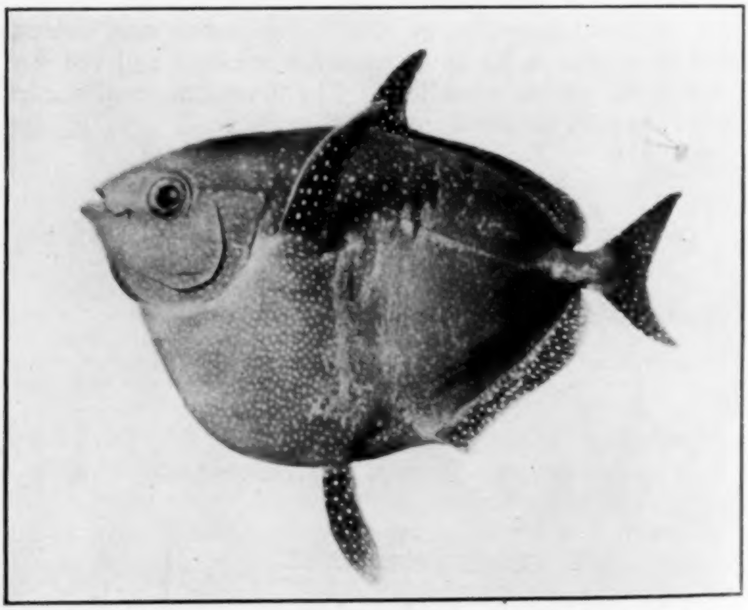


FIG. 1. Photograph of a cast by S. F. Denton of a *Lampris luna* weighing 100 lbs. taken at Honolulu. The triangular space between gill opening and ventral is all occupied by the shoulder girdle.

The one living species of *Lampris* is not related to any other existing fish, constituting an order (*Selenichthyes*) by itself. It bears some resemblance to the pomfret (*Brama*) and to other derivations of the mackerel tribe, but its likeness is superficial only, and not borne out by the skeleton. The bony framework

FIG. 2. Photograph of the shoulder girdle of a large example from Monterey, prepared by E. C. Starks.

shows many unique features, the most important being the extraordinary development of the shoulder girdle. The clavicle and hypocoracoid are excessively enlarged and separated by an interspace, the latter flattened and more or less fan-shaped downward, both bones being proportionately many times as large as in any other fish. The hypercoracoid, pierced by a large foramen, is also much enlarged and so placed that the actinosts or "wrist-bones" of the pectoral fin form a horizontal series, and the long oar-like fin can move only up and down. Behind the coracoids—the postclavicle extends as a long spear-shaped separate bone. Beside these features, the moonfish has very large and expanded pelvic bones, which support strong

ventral fins each with 15 long rays, a marked contrast to the one spine and five soft rays of most spiny-rayed fishes.

The extraordinary diatom beds at Lompoc, Santa Barbara County California, in which four square miles of a Miocene bay are covered to the depth of 1,400 feet with masses of pure diatoms, I have discussed elsewhere.[1] In these beds at one horizon occur untold millions of skeletons of a small herring (*Xyne grex*) while in the upper strata are many remains of predatory fish which have entered what was once a bottle-shaped bay in order to feed on herring. This is evident from the fact that one of the skeletons of a large mackerel has two herring skeletons in what was once its stomach.

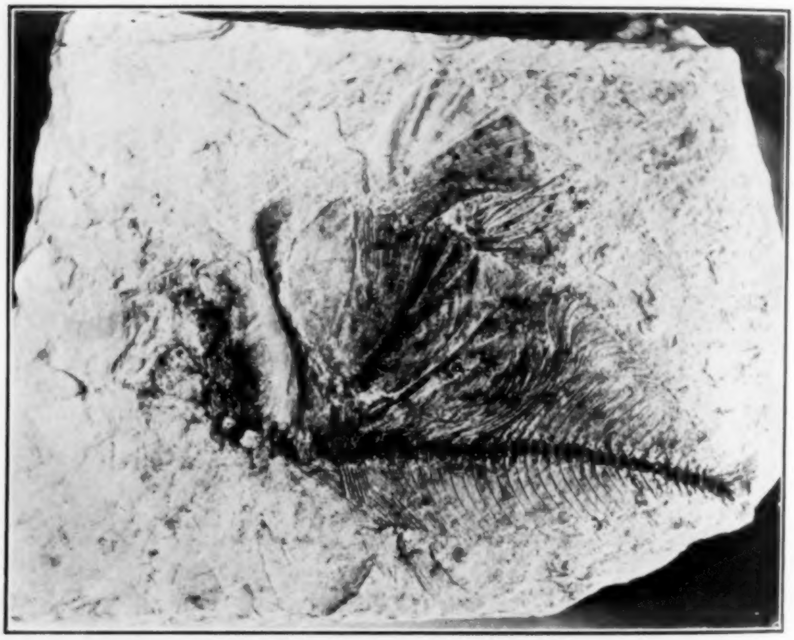


FIG. 3. Skeleton of *Lampris zatima* taken in the Miocene Diatom beds at Lompoc, by E. J. Porteous. In this specimen a portion of the hypocoracoid of the left side appears detached under the other.

Among the relics of these predatory invaders is a very complete skeleton of a second species of moonfish, three feet long by about two broad. From *Lampris luna* it differs in the somewhat fewer vertebræ and fin rays, and in having the hypocoracoid broader, and less rapidly rounded off at its bottom.

[1] See "A Miocene Catastrophe," *Natural History*, XXI., No. 1, pp. 18–22, 1920.

Two smaller specimens, apparently of the same species, but lacking the head and shoulder girdle, had been previously found at Lompoc. To one of these Jordan and Gilbert (J. Z.) had given (in 1919) the name of *Diatomœca zatima*. With the complete skeleton, however, I see no characters by which *Diatomœca* can be separated as a genus from *Lampris*. The extinct moonfish of these Miocene Diatom beds may therefore stand as *Lampris zatima*. The specimen is one of great interest as showing the antiquity of one of the most singular of all living bony fishes, and incidentally with other associated forms, the relative age of the present fish fauna of California.

THE PROGRESS OF SCIENCE

THE POPULATION OF THE UNITED STATES IN 1920

THE Bureau of the Census has now made public the population of continental United States and of the separate states. According to the enumeration of the fourteenth census made this year, the population was 105,683,108, an increase of 13,710,842, or 14.9 per cent., since 1910. In 1910 the population of the outlying possessions, Alaska, Hawaii and Porto Rico, including those abroad on military and naval service, was 1,429,885. The results of the census for these possessions are not yet known and there are no correct figures for the Philippines. It is, however, estimated that the total population of the United States and its possessions is in the neighborhood of one hundred and eighteen million.

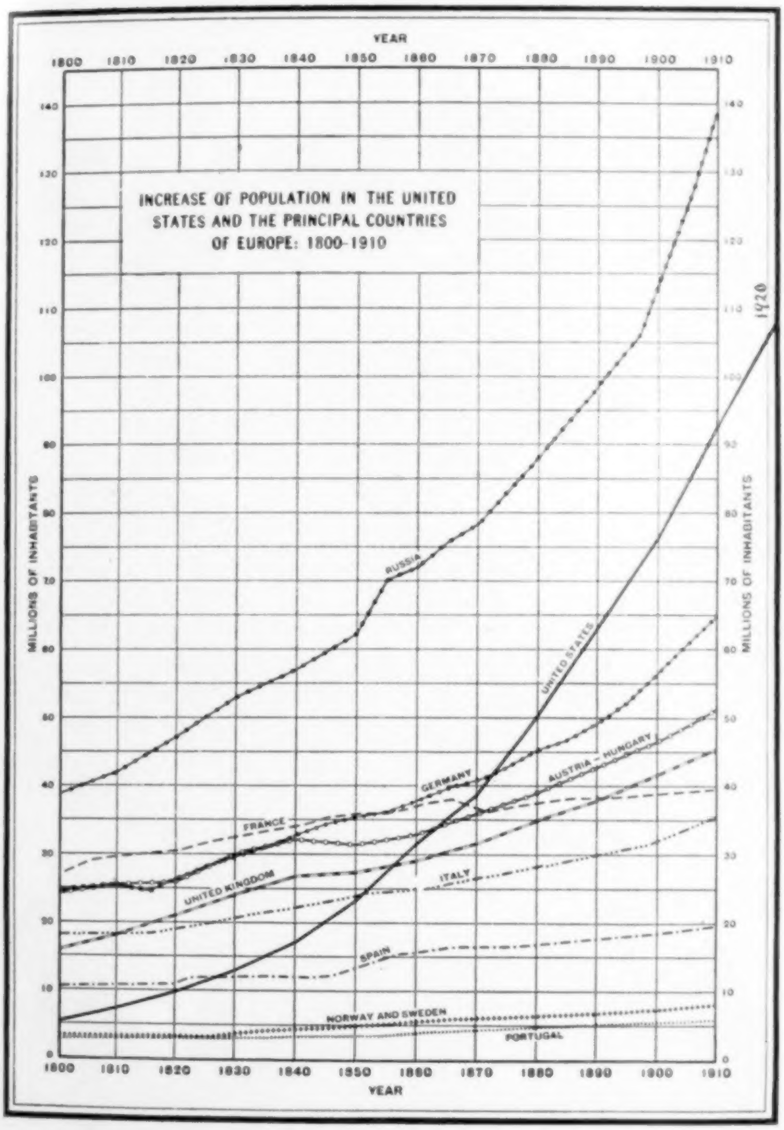
The growth of the country's population, exclusive of the outlying possessions, is set forth in this table:

Census year.	Population.	Increase.	P. c.
1920	105,683,108	13,710,842	14.9
1910	91,972,266	15,977,861	21.0
1900	75,994,575	13,046,861	20.7
1890	62,947,714	12,791,931	25.5
1880	50,155,783	11,597,412	30.1
1870	38,558,371	7,115,050	22.6
1860	31,443,321	8,251,445	35.6
1850	23,191,876	6,122,423	35.9
1840	17,069,453	4,203,433	32.7
1830	12,866,020	3,227,567	33.5
1820	9,638,453	2,398,572	33.1
1810	7,239,881	1,931,398	36.4
1800	5,308,483	1,379,269	35.1
1790	3,929,214	—	—

The fact that the increase in population was more than two million less in the last decade than in the one preceding is due to war conditions and especially to the cessation of immigration and the lack of the children that would have been born to immigrants. The actual fatal casualties of the war are a minor factor, perhaps not more than one tenth of the deaths from the epidemic of influenza, but a decreased birth rate in the native population due to war conditions may be as important as the failure of immigration.

The curves showing the increase in population in the United States seems to predict a continually increasing increment of growth. Indeed, Dr. H. S. Pritchett, then president of the Massachusetts Institute of Technology, fitted a parabolic curve to the data, and in an article published in THE POPULAR SCIENCE MONTHLY in 1900, predicted that the population of the country would be 114,416,000 in 1920, and over a billion a century hence. In a recent article in the *Proceedings* of the National Academy of Sciences Pearl and Reed point out that other curves fit the figures equally well, and are more nearly in accord with reasonable expectation. They propose a curve taking into account the food supply in a limited area, according to which the period of most rapid growth ended in 1914, and the maximum population of the country will be about two hundred million.

There seems, however, to be no reason why the increase in population should follow a course that can be represented by any mathematical formula. The rate of increase in the United States has been largely due to immigration, in Russia to the large birth rate of an agricultural population with a decreasing death rate, in Germany to developments that supported an industrial population by commerce. As shown on the diagram, the curves for the three

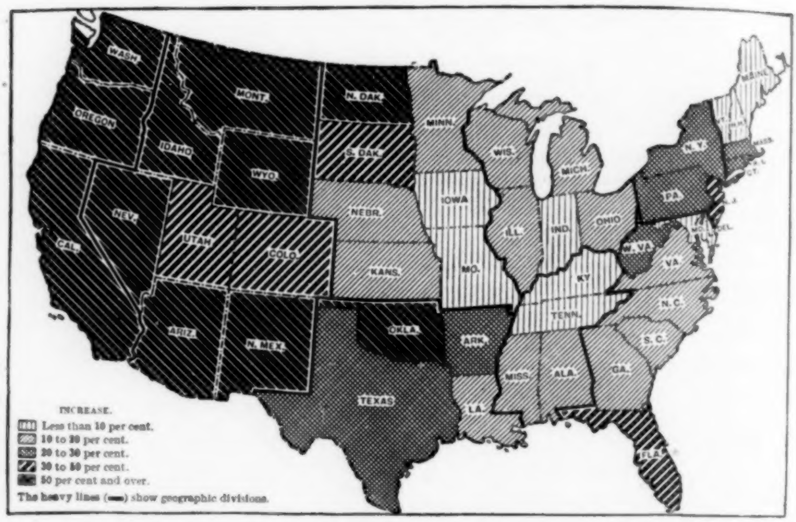


INCREASE OF POPULATION OF THE UNITED STATES AND COUNTRIES OF EUROPE

nations follow a somewhat similar course of increasing increments of population that can be represented by a parabolic equation. The catastrophe of war has altered the course of the curves to an extent unknown except in the United States.

But apart from war, pestilence and famine, there are new causes altering the situation. Two of dominating importance have been the applications of science to agriculture, industry and commerce, enabling the civilized nations to support a popu-

PER CENT OF INCREASE IN TOTAL POPULATION, BY STATES: 1900-1910



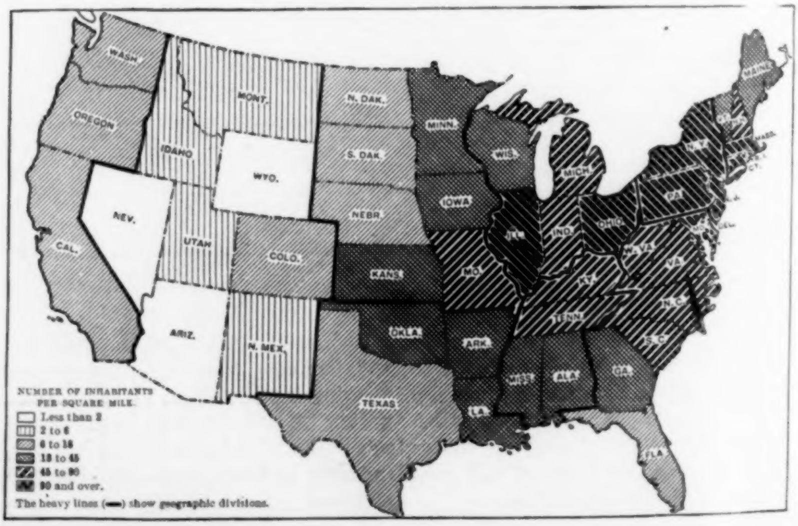
INCREASE OF POPULATION BY STATES. POPULATION PER SQUARE MILE.

lation perhaps four times as great as would otherwise have been possible, and the voluntary limitation of births. The former of these is responsible for the curves of population since 1790. The latter will have an effect during the present century that no equation based on the past can predict.

THE DISTRIBUTION OF THE POPULATION

THE accompanying diagrams show the increase in population by states

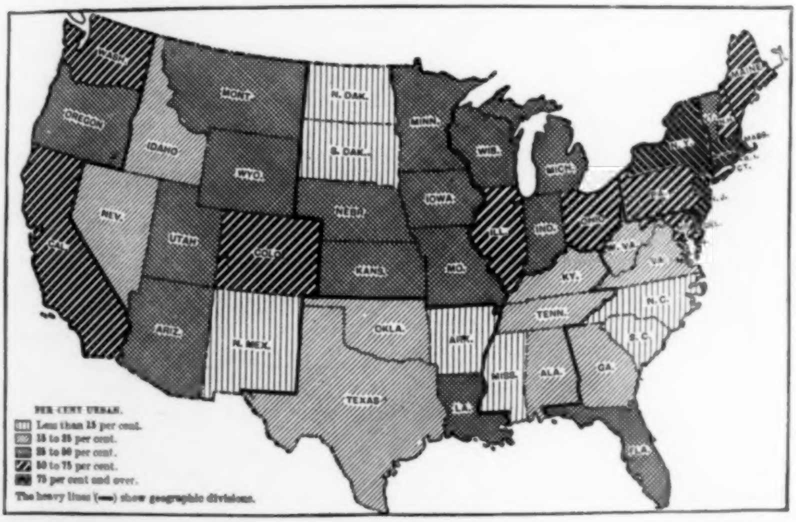
POPULATION PER SQUARE MILE, BY STATES: 1910



according to the census of 1910, the population per square mile and the per cent. of urban population. The population of the several states in 1920 and in 1910 and the per cent. of increase are shown in the figures that follow:

State	Population 1920	Population 1910	P. c. of Gain
United States	105,683,108	91,972,266	14.9
Alabama	2,347,295	2,138,093	9.8
Arizona	333,273	204,354	63.1
Arkansas	1,750,995	1,574,449	11.2
California ...	3,426,536	2,377,549	44.1
Colorado	939,376	799,024	17.6
Connecticut ..	1,380,585	1,114,756	23.8
Delaware ...	223,003	202,322	10.2
Dist. of Col...	437,571	331,069	32.2
Florida	966,296	752,619	28.4
Georgia	2,894,683	2,609,121	10.9
Idaho	431,826	325,594	32.6
Illinois	6,485,098	5,638,591	15.0
Indiana	2,930,544	2,700,876	8.5
Iowa	2,403,630	2,224,771	8.0
Kansas	1,769,257	1,690,945	4.6
Kentucky ...	2,416,013	2,289,905	5.5
Louisiana ...	1,797,798	1,656,388	8.5
Maine	768,014	742,371	3.5
Maryland ...	1,449,610	1,295,346	11.9
Massachusetts	3,852,356	3,366,416	14.4
Michigan ...	3,667,222	2,810,173	30.5
Minnesota ...	2,386,371	2,075,708	15.0
Mississippi ..	1,789,384	1,797,114	0.4
Missouri	3,403,547	3,293,335	3.3
Montana	547,593	376,053	45.6
Nebraska ...	1,295,502	1,192,214	8.7
Nevada	77,407	81,875	5.5
N. Hampshire	443,083	430,572	2.9
New Jersey ..	3,155,374	2,537,167	24.4
New Mexico .	360,247	327,301	10.1
New York ...	10,384,144	9,113,614	13.9
North Carolina	2,556,486	2,206,287	15.9
North Dakota.	645,730	577,056	11.9
Ohio	5,759,368	4,767,121	20.8
Oklahoma ...	2,027,564	1,657,155	22.4
Oregon	783,389	672,765	16.4
Pennsylvania .	8,720,159	7,665,111	13.8
Rhode Island.	604,397	542,610	11.4
South Carolina	1,683,662	1,515,400	11.1
South Dakota.	635,839	583,888	8.9
Tennessee ...	2,337,459	2,184,789	7.0
Texas	4,661,027	3,896,542	19.6
Utah	449,446	373,351	20.4
Vermont	352,421	355,956	1.0
Virginia	2,306,361	2,061,612	11.9
Washington .	1,356,316	1,141,990	18.8
W. Virginia .	1,463,610	1,221,119	19.9
Wisconsin ...	2,631,839	2,333,860	12.8
Wyoming	194,402	145,965	33.2

PER CENT URBAN IN TOTAL POPULATION, BY STATES: 1910



Per Cent. of Urban Population.

The largest relative increase has been the gain of 63.1 per cent. in Arizona, followed by Montana, California and Wyoming. For three States, Mississippi, Nevada and Vermont, there have been small de-

creases in population, the largest being for Nevada, 5.5 per cent.

The director of the census has issued a statement according to which the figures of the present census show that the trend of population from the country to the city has become greatly accentuated since 1910 and that, for the first time in the country's history, more than half the entire population is now living in urban territory as defined by the Census Bureau. That is to say, of the 105,683,108 persons enumerated in the fourteenth census preliminary tabulations show that 54,816,209, or 51.9 per cent., are living in incorporated places of 2,500 inhabitants or more, and 50,866,899, or 48.1 per cent., in rural territory.

At the census of 1910 the corresponding percentages were 46.3 and 53.7, respectively, showing a loss of 5.6 per cent. in the proportion for the population living in rural territory. To show more clearly the change in the proportion of the population living in rural territory now as compared with ten years ago the rural population can be divided into two classes, namely, 9,864,196, or 9.3 per cent. of the total population, living in incorporated places of less than 2,500 inhabitants, and 41,002,703, or 38.8 per cent. of the total population, living in what may be called purely country districts. At the census of 1910 the population living in incorporated places of less than 2,500 inhabitants formed 8.8 per cent., while the population living in purely country districts formed 44.8 per cent. of the total population.

The increase since 1910 in the population as a whole, as before stated, was 14.9 per cent., but during the decade there has been an increase in that portion of the population living in urban territory of 12,192,826, or 28.6 per cent., and in that portion living in rural territory of 1,518,016, or only 3.1 per cent.; and if the comparison is extended to cover the two classes of rural territory, it appears that that portion living in incorporated places of less than 2,500 inhabitants show an increase of 1,745,371, or 21.5 per cent., whereas that portion living in purely country districts shows an actual decrease of 227,355.

TRIBUTE TO THE MEMORY OF JAMES WILSON

Sympathy at the death of former Secretary of Agriculture James Wilson was sent to his family in the form of a resolution adopted at a meeting of the chiefs of the various bureaus of the United States Department of Agriculture. Tribute was paid to the former head of the department for "his patriotic devotion to the interests of all the people, his broad vision, and his practical wisdom." As a token of respect the flags on all department buildings were placed at halfstaff, and remained so until after the funeral, which took place at Traer, Iowa.

Because of the time of the funeral, the department was unable to send representatives from Washington. The department, however, designated Dr. Henry C. Taylor, Chief of the Office of Farm Management, who was in the Middle West; Frank S. Pinney, Federal agricultural statistician at Des Moines; and R. E. Doolittle, Chief of the Central Food and Drug Inspection District at Chicago, to represent it at the funeral.

A floral tribute was sent by officials and employees of the department as a token of esteem for their former chief. The message of sympathy sent the family of Mr. Wilson followed a similar personal message sent by Secretary of Agriculture Meredith. The resolution of the bureau chiefs, forwarded by Assistant Secretary of Agriculture Ball, read:

The members of the Department of Agriculture, feeling deeply the

SIR CLIFFORD ALLBUTT.

Regius Professor of Physics in the University of Cambridge, president of the British Medical Association for the meeting held during the summer at Cambridge. A portrait of Sir Clifford by Sir William Orpen was at the time presented to him by the British medical profession.

loss of their former secretary, James Wilson, of Iowa, desire to express their sympathy with his family and their appreciation of his great services to the United States as Dean of Agriculture, member of Congress, and Secretary of Agriculture. His patriotic devotion to the interests of all the people, his broad vision, and his practical wisdom place him high among those who have deserved well of their country. Beloved as a friend, admired and respected as an official, his example as a man and a statesman is one to which all Americans may turn for inspiration and emulation: Therefore be it

Resolved, That in the death of James Wilson American agriculture has lost one of its greatest exponents and American citizenship one of its finest exemplars.

In token of respect the flags on all department buildings will be placed at half-mast, and a copy of this resolution will be sent to the family.

SCIENTIFIC ITEMS

We record with regret the deaths of Eric Doolittle, professor of astronomy in the University of Pennsylvania; Samuel Sheldon, professor of physics and electrical engineering at the Brooklyn Polytechnic Institute; Frederick Henry Gerrish, emeritus professor of surgery in the Medical School of the University of Maine; Armand Gautier, professor of biological chemistry in the Paris School of Medicine, and Karl Hermann Struve, director of the Berlin Observatory.

Dr. Leo S. Rowe, assistant secretary of the treasury and formerly professor of political science in the University of Pennsylvania, has assumed the directorship of the Pan-American Union at Washington, succeeding Dr. John Barrett, who has retired after fifteen years as head of the union. Sir F. W. Dyson, astronomer royal, Greenwich, has been elected an honorary member of the American Astronomical Society.

American nations, as well as Great Britain, Spain and Portugal, are to be formally invited to participate in the national festivities in November and December in commemoration of the four hundredth anniversary of the discovery of the Straits of Magellan. The festivities will center principally in Santiago and Punta Arenas, the latter the world's southernmost city, where the occasion will be marked by inauguration of important public works, including port improvements, lighthouses in Smith Channel, a highway between Punta Arenas and Natales on the South Atlantic coast and laying of a cornerstone of the Punta Arenas University. It is expected the foreign delegations will visit the straits in December, when warships of the Chilean navy will be assembled there. It was through these waters that Ferdinand Magellan, the Portuguese explorer, first passed in November, 1520.